SCIENCE

23 January 1959

Volume 129, Number 3343

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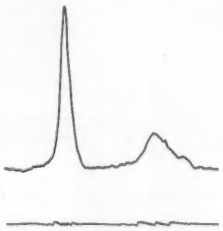

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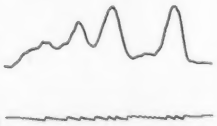

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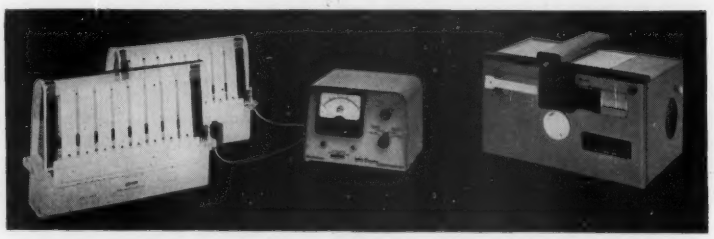

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Letters

Why Not "Get Lost?"

Under the caption, "The lost legion," the editorial of the issue of 3 October [*Science* **128**, 747 (1958)] mourns the effects of team replacement of individually directed effort in current research—(i) loss of contribution to published research results, (ii) loss of scientific freedom under the supervision of an administrator, (iii) loss of identification with specific accomplishment, and (iv) loss of recognition as a productive scientist—this by way of warning the young scientist to be wary of the conditions of his employment if he enters an industrial laboratory. The advantages of the industrial-team situation, "financial and otherwise," deserve closer examination.

"Of the making of many books there is no end." The sheer volume of published reports of bits-and-pieces "research findings," sometimes in multiple audience orientations, has become burdensome to the individual scientist or, in the team approach, to the reference librarian and the bibliographer. (Editorial evaluation of the scientific merit of the manuscripts with any degree of selectivity must be a nightmare!)

Not every young scientist is endowed with the genius, or has attained the breadth of outlook, the maturity in scientific discipline, and the self-discipline, to exercise freedom of research constructively, either for his own progress or for the expansion of scientific frontiers. To the immature scientist, the research administrator may seem a tyrannous instrument of management control, but in most instances, viewed more objectively, he is likely to be mentor, counselor, and friend, seeking to develop and nurture whatever aptitudes are present. This is as much a part of his "management" function as is the expeditious completion of specific projects or programs. The young scientist seeking employment in a research program, whether industrial, governmental, or institutional, should be concerned with both the scientific and managerial quality of the supervision he will receive.

The privilege of publishing and being identified with piddling, fortuitously planned, or uncritically guided and reviewed research is not one that would be highly prized by a young man with serious intentions toward a scientific career.

The notion that the published record of his research is the only acceptable, or even the best, evidence of his productivity as a scientist can be considered an undeserved slur on the perspicacity of senior scientists, research directors, and deans. A competent employment officer for a scientific facility will make a more thorough evaluation of an applicant's qualifications than is possible by mere inspection of his list of publications. An inordinately long list may invite more careful scrutiny of the scientific quality of the publications listed. On the other hand, a record of satisfactory participation in the work of an agency recognized for the quality of its output—supported by appropriate inquiries concerning the scope and nature of the individual's contribution to projects in which he has participated, his growth, and his ability to work harmoniously and constructively with associates—is likely to weigh heavily in making the employment decision. (The harmonious-relations item assumes that the value system of the man in the laboratory coat differs from that of the "man in the gray flannel suit.")

When major advances and "breakthroughs" in science are more and more based on intelligently directed efforts of teams comprising widely assorted varieties of scientists, technologists, and technicians, it may be better for the young scientist to "get lost" in the anonymity of such team efforts, with the prospect of emerging to recognition and identification with significant effort at a later, more mature, stage, rather than to be lost through isolation.

EUGENE D. CARSTATER
Bureau of Naval Personnel, U.S. Department of the Navy, Washington, D.C.

Young men entering upon their careers can draw their own conclusions as to whether they desire anonymity along with opportunities to do research. Will they knowingly enter laboratories where the "get lost" philosophy prevails? I think not. I believe they have the right to know the philosophy underlying the personnel policies of their employers. They should be encouraged to ask questions before accepting employment. That was the thesis of "The lost legion."

In regard to publication of research results, it is debatable whether there are too many books or scientific articles. That is not a question for research directors to decide. One may take the position that research is not completed until results are made available to other workers in the field. Carstater, I fear, is unduly concerned with the "burdensome" tasks of reference librarians, bibliographers, and editors. Let each attend to his own knitting. Release of research results may properly be delayed because of patent applications or for security reasons. Ultimately, I believe, research results should be in the public domain as known "contributions to the sum total of human knowledge." In passing, we should recognize that an employer runs certain risks when a member of his organization releases a report. A competitor may offer him a job at a higher salary or profit by his discovery. If the work of a scientist is not publicized, such dangers are minimized.

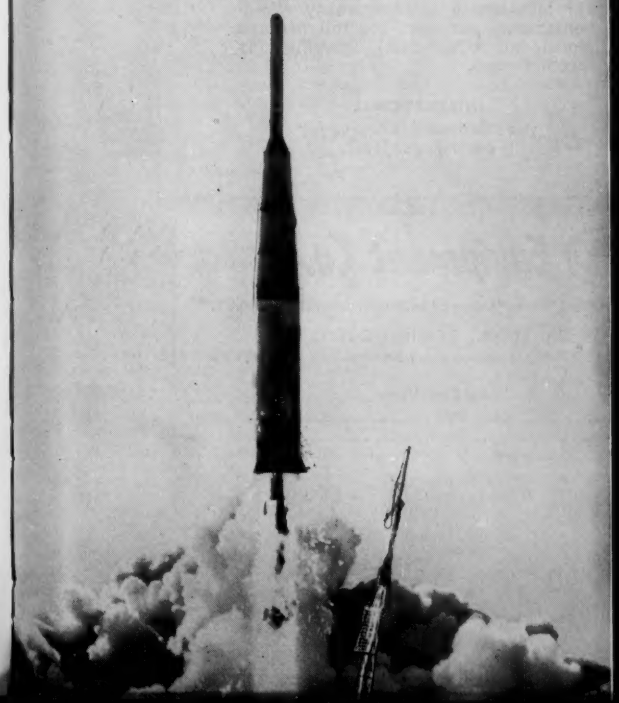
(*Continued on page 218*)

the Pioneer in space

To send the U. S. Pioneer more than 60,000 miles into interplanetary space, Space Technology Laboratories in seven months designed, developed, assembled, and tested an 88-foot combination of three integrated stages with a payload incorporating 36 separate ignition systems. STL's Astrovehicles Laboratory focused on the payload itself and the sensitively related problems of propulsion, weight, and stability. These are in addition to the overall complexities of the structural configuration.

Pioneer, setting new apogees in science and missilery, typifies the achievements STL is making in the advancement of space technology. Those who are able to contribute to and benefit from these developments are invited to consider joining our staff.

Space Technology Laboratories



These programs at STL open a whole new vista in analytical and experimental areas for the advanced technical person whose interests and experience qualify him for work in the following fields: electrodynamics, nuclear physics, thermo-nuclear power, magnetohydrodynamics, solid state physics, communication theory, and the design and execution of physical experiments in interplanetary space. Inquiries are invited.

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Space Technology Laboratories, Inc.
5730 Arbor Vitae Street, Los Angeles 45, California

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Locking the Barn Door First

The Federal Food, Drug, and Cosmetic Act, passed in 1906, has been amended several times to keep it abreast of technological changes, but, until recently, it suffered from a grave and increasingly serious defect. The Act put the burden of testing new food additives for safety on the Government but had no provision for controlling the introduction of new substances. Thus manufacturers could add new compounds—enzymes, artificial flavors and coloring matter, antioxidants, preservatives, and so on—to food products without hindrance; the only recourse for the Government was to test the compounds for safety and, if it found them to be unsafe, to proceed against the producers in court. In effect, this was locking the barn door after the horse was stolen. In fairness to the food industry, it should be pointed out that almost all of the 100,000 or more firms whose products came under the provisions of the Act tested additives thoroughly before general introduction, but a few did not. Herein lay the danger to the public, a danger that increased as vast numbers of new additives were introduced at a rate much greater than that at which Government chemists could make adequate tests.

The Food Additives Amendment of 1958 (Public Law 85-929), passed on 6 September 1958 and fully effective on 6 March 1959, should do much to avoid the danger. The amendment shifts the burden of proving the safety of new additives from the Government to the producer and requires the producer to get a favorable ruling about the additive before it is introduced for public use. To do this the producer presents a petition to the Food and Drug Administration in which he gives the following information about the proposed additive: name, chemical identity if known, conditions of proposed use, relevant data about its intended effect, description of methods for making quantitative determinations, and a complete account of investigations made to test its safety. The petition will be published in the *Federal Register* in general terms as a *proposal* for a future regulation within 30 days after it is filed. Within 90 days (or 180 days if an extension is granted) the commissioner of the Food and Drug Administration will publish the final ruling on the petition. During this period those who have a substantial interest, including scientists who are expert in the effects of chemicals on the food of man and animals, may submit objections.

Scientific experts will thus have a large responsibility under the terms of the amendment. If they raise objections to a proposal, the FDA will take them into account and hold hearings or otherwise gather additional information before making a ruling. If, on the other hand, scientists do not object to a proposed favorable regulation, the FDA will assume that there is general scientific agreement and will put the regulation into effect. This procedure will put it up to the scientists to see that no potentially dangerous additives escape their vigilance, that the barn door is locked first.—G.DuS.

23 January 1959, Volume 129, Number 3343 SCIENCE

Influence of Religion on the Spread of Citrus

The religious practices of the Jews helped effect the introduction of citrus to Mediterranean lands.

Erich Isaac

When Goethe wrote the famous poem beginning "Kennst du das Land wo die Zitronen blühen?" he presumably referred to Italy. Of course, lemons as well as citrus fruits as a whole are not limited to Italy or even to the Mediterranean basin but grow in areas as widely separated as Japan, India, South Africa, and California. Indeed, while citrus is associated with areas which may be described as of Mediterranean climate, it is practically a newcomer to the Mediterranean itself and was introduced there through what is today the least familiar member of the genus—the citron or *Citrus medica* (*1*). This fruit was the first of its genus to be cultivated intensively in the Fertile Crescent of the ancient Near East —namely, Mesopotamia, Syria, Palestine, and Egypt. It owed its distribution into the Roman Mediterranean to the Jews, for whom the citron had become an object essential for the ritual celebration of the holiday of the Feast of Booths. The history of the citron is to me a striking illustration of the part, far too little recognized, played by religion in transforming the landscape.

The citron, *Citrus medica* var. ethrog Engl. (*2*) (see Figs. 1 and 2) belongs to the subfamily Aurantioideae. The citron tree (see Fig. 3) is a small evergreen with irregular and spreading spiny branches, pale green oval and slightly serrated leaves, wingless petioles, and generally perfect flowers. It produces a fragrant golden oval or oblong fruit 4 to 8 inches long with a knobby skin. The citron's protuberant nipple carries a persistent pistil. While in most citrus trees flowering takes place in the early spring, the citron continues throughout the year to produce flowers in varying degrees of abundance. This absence of a period of dormancy makes it, of all the citrus species, perhaps most susceptible to frost damage and limits the range of its commercial cultivation. The citron is mainly cultivated in coastal sections where frosts are infrequent. The development of fruit in interior sections is often inhibited by high temperatures (see *3*, pp. 42–3, 55, 62).

The tree grows on a great variety of soils, provided that the content of organic matter is satisfactory. Soil texture is the most important characteristic. The tree does best on fine sandy loams, although in Tunisia, perhaps the most important commercial citron area of North Africa, plantings are sometimes made on pure sand (*3*, p. 64; *4*). It is interesting that commercial cultivation of a tree so obviously adapted to the tropical rain forest (because of the absence of devices limiting transpiration or evaporation, lack of a regular dormant period, weak root-hair development, and nearly naked buds) (*3*, p. 51) should today occur overwhelmingly in areas of Mediterranean climates.

The author is a member of the department of geography at Temple University, Philadelphia, Pa.

Origin and Spread of Citron

When did the Jew first become acquainted with the citron, or etrog, as he calls it? This is a question which has not yet been conclusively determined and involves the problem of the origin and transmission of the species *Citrus medica*. Nineteenth- and early 20th-century observers, on the whole, concurred in asserting that the citron, lemon, and lime originated on the Himalayan slopes of India and Burma or in the southern part of the Indian peninsula (*5*). There were a few dissident voices, as, for example, E. Bonavia, who came to doubt an Indian origin for the citron when he noted its prevalence on India's western shore, an area which had been most open to foreign influences (*6*). In the 20th century there has been practically unanimous agreement that southwest Asia was the origin of citron, but whether in India or further west in southern Arabia is still a subject of dispute (*7*).

It is surprising that not more attention has been paid to the Arabian peninsula as a possible area of origin of citron, inasmuch as various reports suggest the probability that this area was its native home. Such an authority on citrus as Walter T. Swingle reverses the usual theory that citron spread from India to Media and Persia and then to the Mediterranean by hypothesizing an origin between India and Africa:

"The early advent of the citron in Media and Persia, and subsequent slow penetration into India and China could be explained easily if the citron should prove to be a native of southern Arabia. The bael fruit of India, Aegle Marmelos, has no close relatives in Asia, but three closely allied genera, Aeglopsis, Afraegle, and Balsamocitrus are found in Africa. Citropsis, an African genus of the Near-Citrus fruit trees closely related to the

Asiatic genus Atalantia, has eleven species. It would not be surprising to find midway between India and Africa, in some mountain oasis within the tropical zone in Arabia, the citron growing in a wild state" (*8*).

When did the citron spread from its place of origin—whether this was India or Arabia—to the Fertile Crescent, where the Jew might have found it a part of the regional flora? Traditionally the citron is accepted as the fruit commanded by the Bible for use in the ritual observance of the Feast of Booths, an ancient Hebrew festival originally known as the Feast of Ingathering (see Exodus 23:16; 34:22). Leviticus 23:40 reads: "And you shall take unto yourself on the first day the fruit of a goodly tree, palm branches, foliage of a leafy tree, and willows of the brook, and you shall rejoice before the Lord your God seven days." There is, of course, no reference to the citron here, nor is the etrog mentioned by name anywhere in the Bible. Not until the second century B.C. do we possess ample documentary evidence that the citron was the fruit accepted as "the fruit of a goodly tree." Nonetheless, Jewish religious authority of that period maintained that the citron had always been used and was the original fruit designated by the Bible.

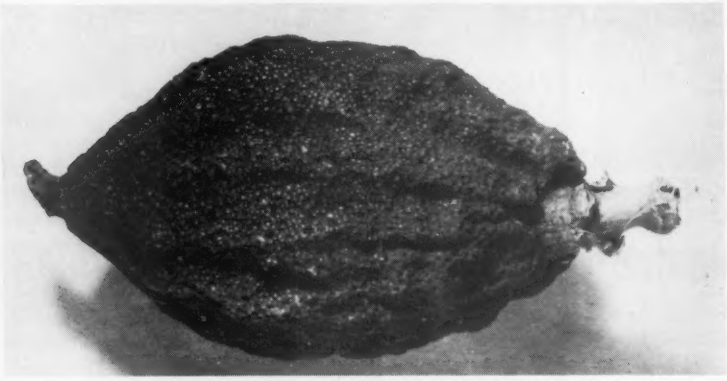

Fig. 1. The citron or etrog. [Frank J. Darmstaedter, Jewish Museum, New York]

Fig. 2. Fruit lying in a silver etrog receptacle (Germany, 18th century). [Frank J. Darmstaedter, Jewish Museum, New York]

This identification of the citron with "the fruit of a goodly tree" commanded at the time of the wanderings in the desert has not gone unchallenged. The argument has been advanced that the Feast of Booths was not celebrated until the time of Ezra and Nehemiah in the fifth century B.C., when the first actual celebration of the feast is described. According to this view, favored by Gallesio, de Candolle, and other authorities, the feast was held then for the first time. Such a theory, of course, presumes a late composition of Leviticus 23:40, since it does not deny the identity of "the fruit of a goodly tree" and the citron but considers that the Jews came in contact with the fruit during the exilic period in Babylonia and brought it back with them to Palestine on their return from the captivity. In the absence of clear proof one way or the other, the first problem is to establish the earliest period at which the citron could have been part of the Levant flora and thus available to the Jews in Palestine.

It is known that in ancient times the lands between the Mediterranean, the Red Sea, and the Indian Ocean were bound together by extensive economic and cultural interchange. Scholars now assert the impossibility of regarding the cultures of the ancient East and Near East as hermetically sealed entities which achieved their flowering independently of the cultural developments in surrounding territories. As early as the fourth millenium B.C. the cultures of Mesopotamia, Syria, Palestine, Egypt, and probably Asia Minor were jointly on the road to civilization, and the contacts were so marked that it may indeed be possible to consider Babylonian and Egyptian civilizations as regional variants of one culture (*9*). Babylonian cylinder seals, pottery types, art motifs, architecture, and early writing all stimulated Egyptian productions of the same nature. Moreover, these contacts were probably not limited to the Fertile Crescent but encompassed the furthermost reaches of the Red Sea. A predynastic ivory showing sailors with a strange craft, which Sir Flinders Petrie interprets as depicting the arrival in Egypt of a ship from Punt (either Somaliland or southern Arabia), is one example of these far-reaching contacts (*10*).

Nor were these contacts limited to the

Fig. 3. Woodcut of branches of a citron tree with fruit. From John Gerard's herbal, *The Historie of Plants* (Printed at London by John Norton, 1597), p. 1278. [W. Hausdorfer, Sullivan Memorial Library, Temple University]

inception of civilization; they continued through the centuries. The Mari Archives, found by a French expedition in 1936, illustrate the freedom of movement in the world of the Fertile Crescent. "Trade was widespread and caravans of merchants were among the commonest sights" (*11*, p. 5). The Biblical picture "of limited movements in the hill country of Palestine, of seasonal migration between the Negeb and Central Palestine, and of easy travel to Mesopotamia and Egypt is, accordingly, so perfectly in accord with conditions in the Middle Bronze Age that historical skepticism is quite unwarranted" (*11*, p. 6). The Bible describes extensive commerce in the tenth century B.C., between Phoenicia, Egypt, southern Arabia, and adjacent regions, as well as with Hittite northern Syria and Cilicia. Elaborate trading expeditions were organized by Solomon and Hiram of Tyre (969–936 B.C.), whose scope embraced the Red Sea, the Indian Ocean, and probably the Mediterranean (Kings I, 9:26; 10:22). This extensive trade was carried on both by sea and by land, land trade having been made possible by the domestication of the camel not long before the 11th century B.C. At the time of Solomon we know that Somaliland and southern Arabia, separated from it by the Red Sea, were considered to be one region. This identification dates back to a period at least as early as the 14th century B.C. (*12*).

We have evidence also of the Egyptians' familiarity with this region. Egyptians traveled from Kosseir to "the divine land" or "the frankincense terraces," terms generally understood to refer to the African shore from Massawa to Somaliland, and to southern Arabia (*13*, pp. 6–9). Punt yielded to the Egyptian kings incense and gold and emeralds (Pliny, xxxvii, 66), and an indication of the closeness of contact is the boast of one traveler of the period of the Middle Kingdom that he had been to Punt 11 times (*13*, p. 7).

We have no certain evidence as to whether the exchanges between these various regions involved the transportation and transplantation of seeds before the 16th century B.C. The first extant record dates back to about 1500 B.C., when Queen Hatshepsut of Egypt imported incense trees "to make for Amon a second Punt in his garden" (*13*, p. 7). Her ships are depicted, in color reliefs, as 30 saplings are brought aboard them in tubs, while the native ruler looks on. We know that trade with Punt continued to the time of Rameses II and Rameses III (*13*, p. 9). Egyptian sailors may also have penetrated into the Persian Gulf, skirting the Arabian coast, inasmuch as they knew the Euphrates, which they called "the reversed waters" because it flows south, while the Nile flows north.

But if Swingle is right in postulating a southern Arabian origin for the citron, and given the fact of both Egyptian and Palestinian contacts with this region, including the actual evidence of transplantation of trees, the likelihood is great that the citron was transmitted from its place of origin in southern Arabia to Egypt and Palestine in the course of trade. Significant in this light is mention in the Mishna (Succah 3:6) and the Talmud (T. Yerushalmi, Succah, p. 53b and T. Bavli, Succah, p. 36a) of an Ethiopian citron as distinct from the Palestinian. This was probably the Yemenite citron, which has been introduced into Israel in recent years by members of the Yemenite community, a community which was, in ancient times, at various periods subject to Ethiopian or Somali rule.

It is reasonable to believe, then, that the citron was transported from southern Arabia and spread throughout the Fertile Crescent, in which areas favorable to its growth abound. Hospitable habitats exist, for example, along the Nile and in Mesopotamia, where the high moisture requirements of the tree can be amply satisfied and where killing frosts are an exception. There is, moreover, evidence for the presence of citron in Mesopotamia in Assyrian times, when what is most probably a citron is depicted on an Assyrian sculpture (*14*). Seeds of *Citrus medica* were found in southern Mesopotamia in the ruins of old Nippur (*15*), and although precise dating is impossible, from their location in the ruins it is evident that they must date back to the fourth millenium B.C. In the second millenium we find the citron referred to frequently in Assyrian medical texts as *"iltakku,"* which corresponds to the Hebrew "etrog"—the citron. Archeological evidence in the form of a model of a citron indicates its presence in Egypt in the 12th century B.C. (*16*).

Citron as "Fruit of a Goodly Tree"

If the citron spread from southern Arabia through the ancient channels of trade to Mesopotamia, Media, Persia, and India, and northwest to Egypt and adjacent countries, it is quite possible that the citron existed in the better-watered coastal plains of the Levant coast in the period of the early kings of Judah and Israel. It may be, too, that its religious significance to the Jews dates back to that period, if not to an era even more remote. Should the citron, on the other hand, not have been part of the Levant flora, the Jews would have made its acquaintance at the latest during their exile in Mesopotamia in the sixth century B.C.

While the citron's presence does not in itself constitute proof that this was the fruit referred to in the Biblical commandment, the likelihood is enhanced by the fact that the citron tree was considered holy in other cultures, including those of India and China. Contact between the Mediterranean shore lands and the Indian realm extended to the religious and spiritual field. The Indian god Kuerva is usually portrayed carrying a citron or lemon and a variety of citron which has five lobes is called "Buddha's hand" by the Chinese (*17*). The golden bullock around which the Jews danced in the wilderness (Exodus 32) and the golden bulls to which temples were built in the reign of Jeroboam (Kings I, 12:28–33) correspond to or are derived from the storm-god familiar

throughout southwestern Asia from 3000 B.C. to the fourth century A.D. The storm-god was represented standing upon a bull, or merely the bull was shown, with the storm-god understood to be invisibly upon it (*18*).

Further supporting evidence for an early identification of the citron with the "fruit of a goodly tree" is the later insistence of the rabbis that the citron is, beyond question, the tree designated. The arguments are primarily those of rabbis living in the second century A.D., but they represent a long oral tradition. Rabbinical Judaism as a whole has never doubted the antiquity and authenticity of the citron, and rabbinic arguments maintaining it appear to be advanced to prevent the Feast of Booths from falling prey to the influences of syncretism—a danger to which this holiday was particularly subject in view of the many pagan parallels. The extent of the danger is well illustrated by the interpretation Plutarch managed to put upon the Feast of Booths. According to him the holiday was "openly dedicated to Bacchus, for they have a feast amongst them called *Cratephora* from carrying palm trees, and *Thyrsophoria,* when they enter into the Temple carrying thyrsi; what they do within I know not, but it is very probable that they perform the rites of Bacchus" (*19*).

Other cults of the Near East used similar objects, such as pine cones, in their celebration; the rabbis' arguments were designed to prove why the citron, and only the citron, could have been meant and should be used at the time of their writing.

Typical of rabbinic arguments for the citron was the insistence that only in the case of this fruit were both fruit and tree goodly (T. Yerushalmi, Succah 3:5). Another rabbi claimed that *hadar* (which is Hebrew for "goodly") is derived from *hadir* meaning "dwelling," referring to the presence upon the tree in all seasons of the fruit in some stage of its growth (T. Bavli, Succah, p. 35). Rabbinic discussion continued throughout the subsequent centuries. Maimonides held that the identification of citron with the "fruit of a goodly tree" was based upon an absolutely trustworthy tradition. Commentators such as Leon da Modena, who were less firmly convinced of the citron's authenticity, saw in the problem an affirmation of the necessity of tradition. He pointed out that the very fact that it was impossible to know what fruit was originally meant emphasized the importance of tradition as a guide to Jewish law (*20*).

Arguments against Early Presence of Citron in Palestine

Recently a historian of citrus has revived the entire question by stating his belief that the citron could not have been growing in Palestine even as late as the return from Babylonia, by which time the celebration of the holiday was, beyond question, established. Another fruit, according to this view, must have originally been used. S. Tolkowsky, assuming an Indian origin for the citron tree, asserts that the tree had not reached Mesopotamia as late as the end of the fourth century B.C. and did not reach Palestine until the second century B.C. He rejects the evidence of the seeds found at Nippur, arguing that these remains constitute evidence of a tribute of rare fruits brought from a foreign country (*21,* p. 43). But the core of Tolkowsky's theory depends upon Theophrastus of Eresos, who wrote during Alexander's campaign in Asia in the fourth century B.C., in his *Inquiry into Plants,* what has become a classic description of the citron. Theophrastus wrote that the citron is called the "Persian or Median apple," and Tolkowsky deduces from this that the citron was not yet growing in Mesopotamia (*21,* pp. 48–51).

According to Tolkowsky, the ancient and authentic "fruit of a goodly tree" was the cedar cone. He claims that the word *hadar* in the phrase *"pri etz hadar,"* instead of being a single word meaning "goodly," is compounded of the Hebrew definite article *ha* and *dar,* the name of a specific tree—the dar tree, *Cedrus deodara,* a holy cedar of India. The change from the cedar cone to the citron resulted, Tolkowsky believes, from the cone's widespread use in pagan cults. According to Tolkowsky, it was Simon the Maccabee who, in order to emphasize the difference between Jew and pagan, replaced the pine cone with the citron, similar to it in appearance, and struck a coin in honor of his reform, supposedly effected in 136 B.C. The citron is depicted on this coin, together with the"lulav," or combination of palm branch, willows, and myrtle prescribed for use on the Feast of Booths (*21,* pp. 52–57).

One objection to Tolkowsky's ingenious theory is that nowhere else in the Old Testament, which abounds in botanical references, is the dar tree mentioned. Moreover, internal evidence from the text of Leviticus argues against his thesis. The fruit of a goodly tree is only one of a number of items which the Jew is instructed in this sentence to take, and it is unlikely from a stylistic point of view that the definite article should precede only one of the objects whose use is commanded (*22*). Equally without foundation is Tolkowsky's theory of the way in which the citron came to be substituted for the pine cone. The coin upon which the citron's introduction was supposedly celebrated was struck, not in 136 B.C., but, as recent scholarship has disclosed, in the first century A.D. (*23*). Figure 4 shows a similar coin. There is ample documentary evidence from this period that the citron had been in use for a considerable length of time.

As for the evidence of Theophrastus cited by Tolkowsky, this may be interpreted rather differently. At the time Theophrastus wrote, the Persian kingdom embraced the entire Fertile Crescent; hence, the phrase "Persian or Median apple" is ambiguous. Nor does the fact that this name was given to the citron in the particular region where the observer upon whose description Theo-

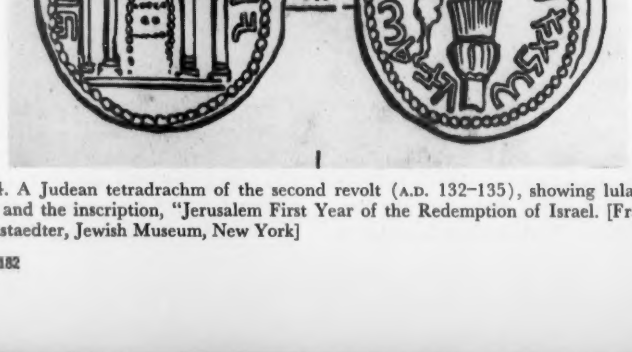

Fig. 4. A Judean tetradrachm of the second revolt (A.D. 132–135), showing lulav and etrog and the inscription, "Jerusalem First Year of the Redemption of Israel. [Frank J. Darmstaedter, Jewish Museum, New York]

phrastus relied encountered it exclude the possibility that the citron was found in other areas where it might have been known by other names. It should be remembered, too, that Theophrastus did not write of plant discoveries but of plants which had long been familiar to the Greek world (*24*). This suggests that the citron was probably cultivated in areas further west than Media or Persia.

But even if we set aside the flimsy and sometimes actually incorrect specific evidence offered by Tolkowsky, we find that his approach to plant distribution is essentially naive. He implies that, in order for the citron to reach Palestine, it must have traveled in an orderly sequence through successively adjoining regions. Thus the citron could not have been in Mesopotamia before its acclimatization in Persia, and acclimatization in Mesopotamia was necessary before the fruit could be introduced into Palestine. Such a view of plant spread is peculiarly inaccurate in the case of cultivated plants, such as the citron, which are dependent upon human beings for their distribution. Palestine is the meeting place of Irano-Turanian, Saharo-Sindian, and Mediterranean vegetation belts. Furthermore, in the Palestinian part of these belts there are many local enclaves characterized by plant associations ranging from tropical to Alpine, within only 40 miles of each other. Thus the chances for the tree's finding a suitable habitat in Palestine are in no way dependent on its prior introduction to Mesopotamia.

Spread of Citron in the Mediterranean Diaspora

But whatever may have been the fruit originally designated by "fruit of a goodly tree" (and there is no reason why the citron should not have been meant), by the first century A.D. the fruit was firmly established. In the reign of Alexander Yanai, who also officiated as high priest, we know of the citron's widespread acceptance through its use in an unexpected manner. When Yanai, in performing the temple service for the Feast of Booths, deviated from the ritual accepted by the mass of the people, the worshippers hurled their etrogim at him (T. Bavli, Succah 4:9; Josephus *Antiquities*, XIII, xiii, 5). So universal was the citron at this period that the Jews considered adopting it as a standard of measure. Rabbi Akiva, a noted scholar of the first century A.D., arguing against such use of the citron, produced one so large that he was forced to carry it upon his shoulder (*25*). In the Talmud, a scale of sizes is established in which the citron ranks at the head and the mustard seed at the foot (T. Yerushalmi, Nazir 1:4).

Fig. 5. A stone from an ancient synagogue in Priene, Asia Minor, showing candelabra flanked on the left by the citron, on the right by the lulav. [Kaiser Friedrich Museum, Berlin]

While it is beyond dispute that the citron was accepted as the "fruit of a goodly tree" at the turn of the Christian era, what is the evidence that the Jews took the citron with them into the Mediterranean as they formed the early communities of the Diaspora? The reason why they might have done so is clear: The citron had assumed great importance to the rabbis and the common man alike. Rigid specifications were laid down by the rabbis to which all citron used for the holiday ritual had to conform: the fruit must be fresh; its skin must be undamaged; the stigma and style which are carried on its protuberant nipple must be in place; and at least the base of the stalk must be attached to the fruit (*26*).

For the citron was more than an object used in ritual performance; it was a fruit with rich symbolical associations. The evidence for this is found primarily in the stories of the aggadists, who are the source of much of the legend and folklore concerning the Bible. According to one aggadist, the etrog corresponds to the heart of man (*27*). The citron tree, goes another aggadic legend, was the tree of knowledge of good and evil (*28*). Of course Western civilization is familiar with the apple, but this legend, too, grew from aggadic sources, and throughout the Middle Ages the two legends interlocked so that apple and citron were frequently substituted for one another in common usage (*29*).

Not only to the rabbis and aggadists did the citron assume symbolical importance; the common man participated in these attitudes. While no specifically religious symbols appeared in Jewish art until about 40 B.C. (*30*, vol. 1, p. 273), from this time on the citron was one of the most common motifs on Jewish inscriptions, tombs, mosaics, and ritual objects (Fig. 5). Indeed, to a foremost student of Jewish art, the presence of the citron on unquestionably Christian remains is sufficient to indicate the presence of Jews or Judaizing influences (*30*, vol. 2, p. 97).

The accompanying map (Fig. 6) shows the universality of the etrog symbol in the Jewish Diaspora of the early Christian centuries, as well as the extent of Jewish settlement both in towns and on the land. The existence of the symbol on Jewish remains in a given area does not in itself constitute proof that the tree was grown there. Nor does the absence, to date, of the symbol in areas where we know Jewish communities to have existed mean that further archeological investigation would not disclose the citron in these places as well. The probability is great that wherever Jewish communities existed in the Mediterranean world there was common usage of the citron symbol, and that wherever it was at all practicable the Jews not only drew, but also grew, the fruit.

The map further shows, by what is at least an interesting coincidence, that the centers of early Jewish population (with the exception of Israel, these centers are no longer Jewish) roughly coincide with the centers of present-day Mediterranean citrus production—that is, Mediterranean Spain, Algeria, Sicily, Calabria, the Nile delta, and the Levant coast of Israel, Lebanon, and Syria. Morocco and Tunisia are not today primary centers of citrus production, but it is worth noting that one of Morocco's two producing centers for citrus, the Sebu basin (especially the area between present-day Meknes and Fez), coincides with the region of Volubilis, an early Jewish pale. Significantly, moreover, Morocco and Tunisia remain important producers of citron, and up to very recent times the Tunisian citron even supplied sections of the Palestinian market. Morocco continues today to be a source of supply for the American market (*31*). It is my belief that it is the antiquity of citrus culture, originally introduced in these regions by the Jews, for whom cultivation of other citrus species was a by-product of citron cultivation, which explains the persistence of this horticultural specialty. It is interesting, in this light, that citron trees in these areas, certainly from the tenth century on, repeatedly served as grafting stock for other varieties of citrus, particularly the orange (*21*, pp. 105–107; 32).

As Jewish communities multiplied in the Mediterranean Diaspora, references to the citron among non-Jews increased and became more accurate. In the period of Theophrastus the citron was considered inedible by the Greeks (*33*), and as late as about A.D. 70 Pliny recorded the same opinion of the citron (*Historiae Naturalis*, XII, vii, 1). That Jews, on the other hand, ate citron we know from the practice of the period of the Second Temple, when children ate citron on the last day of the Feast of Booths (T. Bavli, Succah 4:7). Coincident with the increased dispersal of Jewish communities came the recognition, by the Romans, that the citron was edible. Indeed, citron recipes became common, and the fruit was frequently prescribed for its supposed medicinal or magical virtues (*34*).

While there is no clear documentary evidence to show that the Jew introduced citron into the Mediterranean, the first records of the cultivation of citron from Jewish and from non-Jewish sources are from those areas with the oldest and largest Jewish communities. Thus, citron is found in the Peloponnesus, one of the earliest centers for Jews outside Palestine, probably at the end of the first century A.D., and there is definite proof of its cultivation there in the second century A.D. (*21*, pp. 75, 77). We know that in Mauritania, another area of early Jewish settlement, the citron was intensively cultivated at the beginning of the Christian era (*21*, p. 69). Clearly, if the citron was grown at all in Italy at this time it was still a rarity. The only really reliable evidence pointing to the presence of citron trees in Italy, where for a long time after their acclimatization they were known as "Palestinian trees," comes from Pliny, who mentioned the citron as one of those trees "which have already become naturalized with us" (*Historiae*

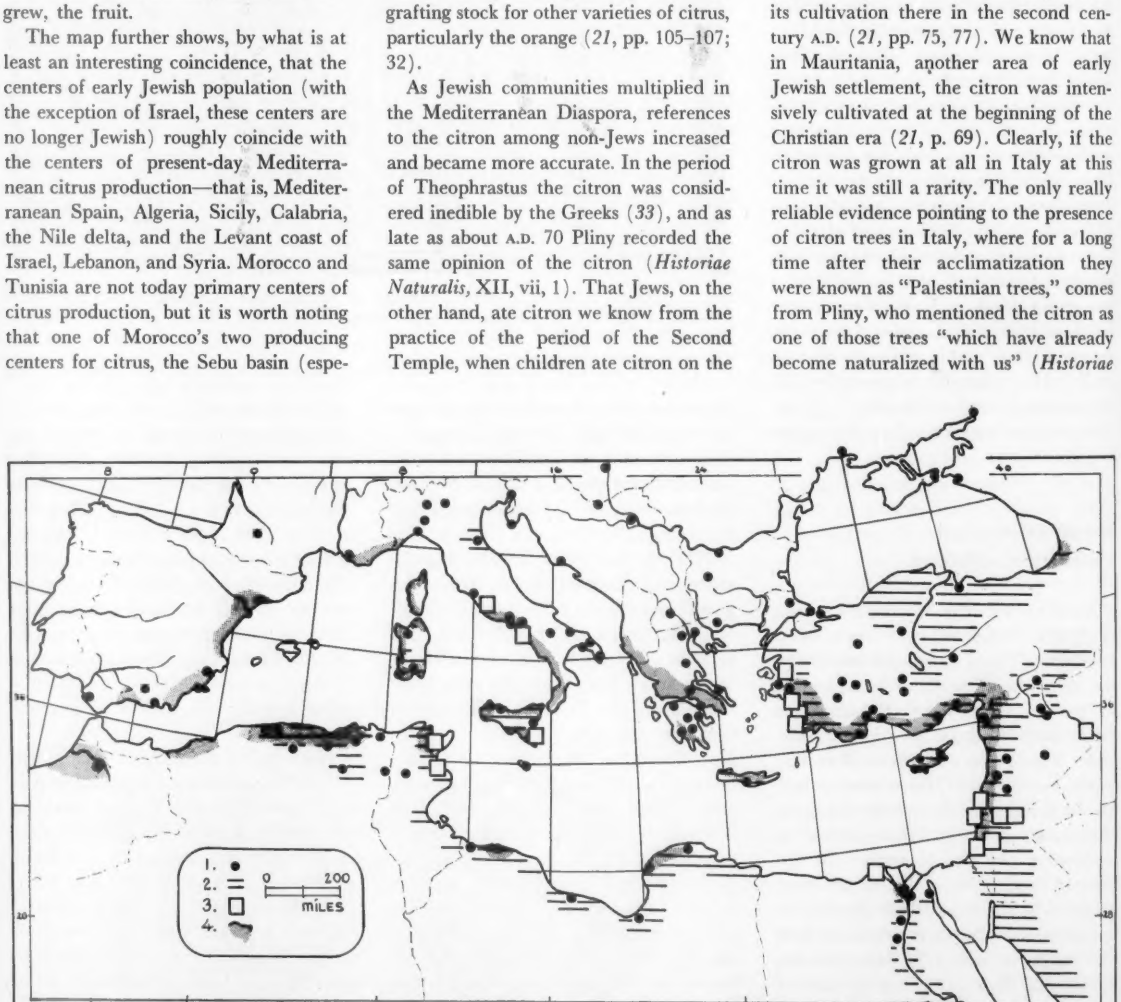

Fig. 6. The Jewish Diaspora of the early Christian centuries (*39*). (1) Cities with large Jewish populations before the fourth century A.D. (so far as known); (2) dense Jewish rural settlement before the fourth century A.D. (so far as known); (3) area in which the etrog has been found depicted in situ; (4) areas of contemporary commercial citrus production.

Naturalis XII, vii, 1). The citron appears in Roman art around the middle of the first century A.D., when it is found as a relief in the tomb of the Haterii on the Via Labicana. It occurs on wall paintings in Pompeii showing Jewish or Judaizing influences (*30*, vol. 2, p. 55). But although the citron was present in Italy, it was by no means a common fruit, for at the beginning of the fourth century its cost was still relatively high. In Diocletian's edict of A.D. 301, fixing prices, the maximum price for a citron was set at 24 denarii, whereas a melon was set at 2 denarii (*35*).

Role of Jews in Introduction of Other Citrus Fruits

It is highly reasonable to assume that the Jews, to whom the citron was such a vital part of religious observance, were the prime agents in spreading the fruit and, as a by-product, in making it acceptable to the non-Jewish population. Only the most perfect fruit might be used as etrogim, and for the less perfect citron it was also desirable to find a market. It is, moreover, highly probable that the Jews introduced other citrus fruits along with the citron and at least contributed to their spread. It is commonly assumed that the orange and lemon were introduced into Europe in the tenth century by the Arabs and that before this time the fruits had been unknown there. But it is scarcely likely that in a period when citron was intensively cultivated, the orange and lemon, fruits which have similar requirements, should have been overlooked by the Jews. Indeed, the Talmud mentions the "sweet citron" (T. Bavli, Shabbath, p. 109b) and the "spherical citron" (T. Bavli, Succah, p. 35a), both of which are now taken to refer to the orange. Different fruits of the genus *Citrus* tended for a long time to be given a common name, and the particular fruit was distinguished by the adjective applied to it. As late as the tenth century the Persian physician Abu-Mansur Muwaffaq stated that oranges were commonly called "sweet lemons" (*21*, p. 106). S. Tolkowsky was the first to point out that sufficient evidence exists in Hellenistic and Roman art and literature for us to conclude that the orange and lemon were known in the early Christian centuries (*21*, pp. 100–109). What appears most probable is that cultivation of citrus other than the citron died out in the centuries following the fall of the Roman Empire and that the fruits were reintroduced by the Arabs.

The Jews became outstanding horticulturists in the Mediterranean in the first centuries of the Christian era, and it may well be that the Jew's need to grow citron was a factor in leading him to pursue this vocation. In Tarragona and Granada Jews owned the vineyards and orchards surrounding the towns (*36*). Jewish ownership of groves in the Balearic Islands at the end of the fourth century is likewise established (*37*). The extent to which Jews were cultivators of land can be shown in Sicily, a center of early citron production, where, by the beginning of the seventh century, Jews worked as *coloni* in large numbers on the lands of the church. In Lombardy the extent of actual Jewish landownership attracted the adverse criticism of Pope Gregory I, who wrote to the Bishop of Luna in Tuscany that he thought it wrong that the Jewish farmers should use Christian slaves on their land. He suggested that the Jews only be permitted to employ Christians as serfs (*38*).

In spite of increasing restrictions imposed on Jewish landownership in Christian Europe from the fifth century on, as late as the twelfth century Jewish horticultural skill was famous. When King Roger of Sicily wished to commence sericulture in Corfu, he imported a community of Jewish horticulturists into that island. It is highly probable that this marked the beginning of the growing of citron on Corfu, which was subsequently to become a primary source of etrogim for the Jews throughout northern Europe.

The spread of citron and the attendant horticultural arts from Palestine to other Mediterranean shores is an instance of the influence of religion upon the development of the cultural landscape. The difficulty of separating out religiomagical motivations from economic, political, and other forces has led to the minimization of the former. The geography of religion is, as a result, the least developed of all geographic specializations. In fact, it has largely become a cartographic exercise in mapping the distribution of obviously religious categories—for example, distributions of population according to religion; distributions of churches, mosques, and other types of religious architecture, and so on. While there is no gainsaying the usefulness of such mapping, it stops short of examining the influence of religion on regional economic structures. Failure properly to take into account religious forces in the modification of the landscape frequently leads to insufficient explanations of historical processes. The early history of citrus in the Mediterranean cannot be explained in terms of economic or social needs but depended upon the religious beliefs and observances of a people, based, in turn, upon rabbinic interpretation of a Biblical commandment. If we accept the view that oranges and lemons were introduced with the citron at an early period, the disappearance of all types of citrus except the citron can similarly be explained only in terms of religious motivation. In the anarchy following the fall of the Roman Empire there was no group to whom the cultivation of oranges or lemons was of vital interest; the citron alone continued to be grown without interruption, and frequently in the face of great difficulties, because it fulfilled the religious obligations of one segment of the Mediterranean population.

References and Notes

1. *Citrus medica* is, indeed, of such minor importance in world trade that the Foreign Agricultural Service of the U.S. Department of Agriculture does not compile data on the world trade in citron.
2. The citron is also known as *Citrus medica cetra*, *C. medica* var. *lageriformis* Roem., *C. limon scabiosa*, *C. media* var. *cucurbitina* Risso & Poit. and *C. medica* var. *cylindrica* Hort.
3. See H. J. Webber in *The Citrus Industry*, H. J. Webber and L. D. Batchelor, Eds. (Univ. of California Press, Berkeley and Los Angeles, ed. 1, 1943), vol. 1.
4. J. H. Burke, "The Citrus Industry of North Africa," *U.S. Dept. Agr. Foreign Agr. Rept. No. 66* (1952), p. 113.
5. A. de Candolle, *L'Origine des plantes cultivées* (Paris, ed. 5, 1912), p. 142; W. Roxburgh, *Flora Indica* (Serampore, India, 1832), vol. 3, p. 392; J. D. Hooker, *Flora of British India* (Reeve, London, 1875), vol. 1, pp. 484–517; D. Brandis, *Indian Trees* (London, 1906), p. 122; E. Goetze, *Ein Beitrag zur Kenntniss der Orangengewächse* (Hamburg, 1874), p. 16. After the turn of the century the same view was presented, notably by Sir George Watt in *The Commercial Products of India* [(London, 1908), p. 325].
6. E. Bonavia, *The Cultivated Oranges . . . of India and Ceylon* (Allen, London, 1888–1890), p. 70.
7. I am indebted to E. Milne-Redhead, T. A. Russell, and George Taylor of the Royal Botanical Gardens, Kew, England, and to H. L. Li of the Morris Arboretum, Philadelphia, Pa., for their clarification of current thought on the question of the native home of *Citrus medica*.
8. See W. T. Swingle in *The Citrus Industry*, H. J. Webber and L. D. Batchelor, Eds. (Univ. of California Press, Berkeley and Los Angeles, ed. 1, 1943), p. 397. It is almost certain that there were floral and faunal transfers, attendant on ancient human migrations, between the monsoonal realm of southwest Asia, southern Arabia, and eastern Africa, although the directions and sequences of such dispersals and migrations cannot be established with certainty. Six-rowed barley, developed from *Hordeum agriocrithon*, was probably introduced from India through southern Arabia into Ethiopia. By 4000 B.C. this had become the staple of the Egyptian Badari [see H. von Wissmann, *Erdkunde* 11, 91 (1957)]. Southern Arabia also plays a prominent role in the dispersal of millet and the distribution of Zebu cattle [see E. Werth, *Botan. Jahrbücher* 73, 106 (1943)]; see also the comparison of southern Arabian palms with those of Africa and southwest Asia in M. Burrett, *Botan. Jahrbücher*, 73, 175 (1943).
9. R. Heinegeldern, *Diogenes* No. 13, 82 (1956).

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19. Plutarch, *Symposiaca Problemata* IV, 5.
20. L. da Modena, quoted by I. Löw, *Die Flora der Juden* (Vienna and Leipzig, 1924–1926), vol. 3, p. 287.
21. S. Tolkowsky, *Hesperides: A History of the Culture and Use of Citrus Fruits* (Bale, London, 1938).
22. I am indebted to Prof. Ezekiel Kutscher of the Hebrew University, Jerusalem, for the stylistic analysis of the text.
23. L. Kadman, *Israel Exploration J.* 7, 62 (1957).
24. Pauly-Wissowa, in *Real Encyclopädie der Classischen Altertumswissenschaft* (Stuttgart, 1940), vol. 7, suppl., pp. 1435–1465.
25. The etrog referred to in T. Bavli, Succah, p. 36b, may have been very large indeed. J. H. Burke ["The Citron Industry of North Africa," *U.S. Dept. Agr. Foreign Agr. Rept. No. 66* (1952), p. 39] states that some of the citrons produced in North Africa weigh as much as eight pounds each. In 1673 a certain Padre Gonsales wrote: "In Calabria I saw very fine citrons weighing several pounds apiece, but those at Tripoli, in Syria, are still bigger, as big as ordinary melons, so that I dare not state their weight since it would sound incredible" (*Reyse vanden eerw.* Pater P. A. Gonsales, *Minder-Broeder Recollect.* (Antwerp, 1673), vol. 2, pp. 372–373.
26. See "Etrog," in *Encyclopaedia Talmudit*, M. Bar Ilan and J. Sevin, Eds. (Jerusalem, 1949), vol. 2, p. 129.
27. N. E. Rabinowitz, Ed., *Midrash Hagadol Levayikra* (New York, 1932), p. 587.
28. J. T. Berlin, Ed., *Breshith Rabbah* (Berlin, 1912), p. 140.
29. I. Löw, *Die Flora der Juden* (Vienna and Leipzig, 1924–1926), vol. III, p. 229.
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37. G. Caro, *Die Juden in ihrer Wirtschaftlichen Betatigung im Mittelalter* (Frankfurt, 1904), p. 423.
38. I. Schipper, *Anfänge des Kapitalismus bei den Abendländischen Juden im frühen Mittelalter* (Vienna and Leipzig, 1907), p. 13.
39. The main sources used in the mapping of the Diaspora were J. Oehler, *Monatschr. Geschichte u Wiss. Judentums* 30, 292–302, 443–452, 525–538 (1909); J. Juster, *Les Juifs dans l'empire romain* (Paris, 1914); J. B. Frey, *Corpus Inscriptionum Iudaicarum* (Rome, 1936). The distribution of the citron in archeological evidence is mainly based on material presented by E. R. Goodenough in *Jewish Symbols in the Greco-Roman Period* (Pantheon, New York, 1953–1954), vols. 1–4.

CURRENT PROBLEMS IN RESEARCH

Reappraisal of the Soil

Pedogenesis consists of transactions in matter and energy between the soil and its surroundings.

C. C. Nikiforoff

What is soil? Soil technologists and agronomists define soil as the medium which provides the foothold and the mineral nutrients for land vegetation. Agronomy inherited this old concept of soil from the tillers of land, for whom the soil is just the "dirt" supporting their crops. This simple utilitarian concept of soil is so deeply entrenched in people's minds that one may wonder whether it would not be less confusing to leave the term *soil* entirely to agronomy and coin some other name for the geochemical surface formation which is referred to in agronomy as "the soil."

Without agronomic bias, the soil or its geochemical equivalent might be defined as an excited skin of the subaerial part of the earth's crust. In order to clarify this definition it is necessary to define *earth's crust* and to say a few words about the nature of the excitation of its integument.

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Earth's Crust

The term *earth's crust* is intended to designate the 10-mile-thick outermost layer of the silicate geochemical shell. This shell, the probable thickness of which is in the neighborhood of 100 kilometers, consists of igneous rocks and their derivatives. Igneous rocks are largely made up of oxygen, silicon, and a half-dozen other elements, including aluminum, iron, calcium, potassium, sodium, and magnesium. These eight elements make up more than 98 percent of the mass of igneous rocks. Less than 2 percent of the shell is made up of other elements, the contents of which range from several tenths of one percent (for titanium) to mere traces.

Oxygen makes up only a little less than half of the whole mass of the shell, but, because its density is low, it constitutes by volume more than 90 percent of the bulk. Silicon is the next most abundant element in the earth's crust. It makes up about 27 percent, by weight, of igneous rocks (*1*). The density of silicon, however, is much higher than that of oxygen; hence, in igneous rocks silicon constitutes less than 1 percent of the volume. Aluminum and iron are the only other elements each of which makes up more than 5 percent of the mass of the earth's crust (*1*).

On the average, there are about 63 atoms of oxygen in every 100 atoms making up the earth's crust. All the oxygen is combined with other elements to form various oxides, which are arranged into crystalline lattices of rock-forming minerals, such as quartz, feldspars, and pyroxenes.

Crystals of silicates, which make up more than 90 percent of the mass of igneous rocks (*1*), are essentially oriented clusters of large oxygen ions, thoroughly interbraced by the much smaller ions of silicon and aluminum and holding ions of other elements in the interstices of the

silicon-oxygen framework (*2*). Individual atoms in a crystal are arranged in such a way that inside the lattice all valences are fully satisfied, all electronic charges are balanced, and each atom is accommodated according to its space requirement and coordination habit (*3*). These rules do not apply to the atoms on the surface of crystalline structures, which carry free charges, possess some amount of open valence, and have their coordination number only partly met. The electrostatic charges and open valences of these atoms serve as the root of the surface energy of crystalline structures and provide the braces uniting various crystals into a massive rock.

On the surface of the earth's crust, solid rocks make contact with the atmosphere and become subject to weathering, the general trend of which is toward the ionic dispersion of matter. In the course of this process, somewhere between the initial and final stages, the solid rocks are broken down into loose earthy material. This intermediate product of weathering consists of sand, silt, and clay, with an admixture of coarser fragments of initial rocks.

By far the greater part of this loose material does not remain in place but is shifted and assorted by running water, wind, or glaciers and is redeposited in other places. As a result of these movements the thickness of regolith varies, from place to place, from virtually nothing to several kilometers (*4*).

This is the loose mantle of the earth's crust, the outermost layer of which, having a thickness of hardly more than 2 or 3 meters, is permanently excited and transformed into soil.

Exogenic Excitation

Excitation of the skin of the earth's crust is caused by the continuous application to it of extraneous energy. Energy flows toward the surface of the earth from two different sources. Part of it is cosmic and flows from the space outside the earth. Another part is generated in a slow atomic decay of radioactive elements inside the crust. For brevity, let us call these types vadose energy and juvenile energy, respectively.

Solar radiation annually intercepted by the earth and representing the bulk of vadose energy amounts to about 1.27×10^{21} kcal (*5*). About 57 percent of it is reflected from the clouds, absorbed in the atmosphere, or scattered through space (*6*). The remaining 43 percent, equivalent to about 5.5×10^{20} kcal per year, passes through the atmosphere and reaches the surface of the earth, by which it is absorbed and where it is transformed into heat and chemical energy. The surface of the earth has an area of about 5.1×10^{18} cm^2. Hence, on the average, the rate of inflow of vadose energy amounts to about 108 kcal/cm^2 per year.

Annual rainfall on the land amounts to about 1.23×10^{14} metric tons, or roughly 120,000 km^3 of water. About 78 percent, or some 96,000 km^3, of this water is provided by evaporation from the land (*7*). Evaporation of this water requires about 5.8×10^{19} kcal, or some 36 percent of the solar radiation received by the land. Thus, on the average, more than one-third of the incoming energy is consumed in the evaporation of water, leaving about 68 kcal/cm^2 per year to warm up the absorbing body.

Raising the temperature renders the receiving body radiant; hence, the earth's surface sends back into the atmosphere a part of its energy in the form of infrared radiation, which is largely absorbed in the air and warms up the lower layer of the troposphere. Another part of this heat generated on the surface of the land is transferred into the ground. Such an inflow of vadose energy, however, does not penetrate the ground very deeply. At a distance of only a few meters from the surface it meets the counterflow of outgoing juvenile energy.

The average thermoconductivity of the earth's crust is 0.004 calories (*8*), and the average geothermal gradient is about 30°C per kilometer. Under these conditions the flow of juvenile heat is very slow indeed. The pressure of this current of energy, however, is great, as is shown by its ability to check the many-times-faster inflow of the vadose energy at such a short distance from the point of entrance of this energy.

Thus, the skin of the subaerial part of the earth's crust, having a thickness of only a few meters, might be conceived of as a sort of thermal pool into which flow two streams of energy. The capacity of this pool is determined by the temperature above which the excess of energy is discharged into space. The inflow of juvenile heat contributes very little of its own energy to the pool, but it buffers dissipation of the vadose heat into the ground and serves to keep a fairly high energy level in the pool. This is the extraneous energy which excites the skin of the earth's crust. The rate of inflow of this energy varies from place to place and determines the degree of excitation of the receiving system at any given point.

Soil Dynamics

Continuous charging with extraneous energy transforms the thin exterior layer of the relatively inert crust of the earth into a thermodynamic system. The performances of this system, referred to collectively as soil dynamics, represent the totality of movements which continuously are made throughout the system. Some movements are very slow, whereas others are made in a flash. Some movements consist of mere oscillation of an atom in the crystalline lattice; others result in transporting millions of tons of dissolved substances from the continents into the oceans (*1*), so that some movements cover just a fraction of 1 angstrom while others extend for many kilometers.

Every movement, whether large or small, is a change in place or position and represents a certain amount of work, which consumes an equivalent quantity of energy. The amount of work which might be performed by the system depends upon the free energy of this system. If the intrinsic energy of the system is exhausted and the system is not recharged, then its activity comes to a standstill. Ceaseless excitation of the soil system by vadose energy enables it to function throughout geological history.

An essential part of soil dynamics consists of movements in the atomic and subatomic regions—that is, movements representing various chemical reactions. An ordinary chemical reaction is caused by the collision of sufficiently excited molecules or ions (*9*). Excited ions of the solid phase of the soil system, however, are mounted in a crystalline lattice on the surface of solid particles. They may rotate or oscillate but cannot move from their nests unless kicked out by other ions. Hence, collisions take place when free ions, disseminated in the liquid and gaseous phases of the soil system, bump into the mounted ions.

Reactions between the solid and nonsolid phases of the system show that this part of soil dynamics consists largely of acts of surface chemistry and bring out the significance of the comminution of soil solids. The rate of a chemical reaction is, of course, proportional to the active mass of the reactants. The active mass of soil solids consists essentially of the excited ions which form the monoionic surface film of solid particles and, thus, is proportional to the specific surface of this material or inversely proportional to the particle size. The active mass of dispersed 1-micron clay presumably is more than 100 times greater than that of fine sand.

Oxidation, Carbonation, Hydration

The surface of soil-solid particles is bombarded especially by the free ions of oxygen, carbon dioxide, hydrogen, and hydroxyl of dissociated water as well as by the whole, bipolar water molecules. When water vapor condenses to rain water, some quantities of free oxygen, carbon dioxide, ammonia, and other gases are dissolved in this water.

The rain water which falls on land brings with it about a billion tons of dissolved free oxygen and almost an equal amount of dissolved carbon dioxide (*10*). Like all natural waters, it contains also some free hydrogen and some hydroxyl ions.

A certain part of this water is intercepted by vegetation or evaporates from the surface without entering the ground. The remaining part percolates slowly through the porous ground and comes into intimate contact with mineral particles; this allows dissolved free ions to react with the ions on the surfaces of these particles.

Steady inflow of free ions of oxygen, carbon dioxide, hydrogen, and hydroxyl, as well as inflow of polar water molecules, results in the conspicuous oxidation, hydration, and carbonation of the excited skin of the earth's crust. Indeed, various other ions, including those of calcium, potassium, iron, and sulfur, some of which might be washed by rain from the air but which are largely kicked out by hydrogen ions from broken crystalline lattices, also appear in solution and take part in reactions, thus inflicting other changes in the composition and structure of the system.

Oxidation results in fixation of free oxygen. Since dry oxygen is more or less inert, the free oxygen dissolved in rain water is the principal agent. Oxidation is essentially a surface phenomenon, and free oxygen brought into the system is consumed largely near the surface. The chief recipients of it are ferrous iron, which is oxidized to ferric compounds, and organic carbon, which is oxidized to carbon dioxides.

Carbonation, or enrichment of the system in carbon, is manifested in two different forms—an enrichment in organic carbon, about which more will be said later in this article, and enrichment in carbonates of "mineral" carbon. Carbonates of alkalis and alkaline earths are among the commonest products of chemical weathering. They remain in the system, however, only under certain conditions, which are not universal. When there is an excess of CO_2 they change to easily soluble bicarbonates, pass into solution, and, if there is sufficient rainfall, may be quantitatively leached from the system to be carried to the sea or into the deeper parts of the earth's crust.

Hydration leads to the general enrichment of the system in water and to formation of hydrates and hydrated secondary minerals such as various clay minerals. Hydrolysis is another conspicuous process in the decomposition of silicates. The role of water in soil dynamics, however, is not restricted to hydration and hydrolysis. Water acts in so many different ways that its role cannot be adequately described in a short article.

Exergonic and Endergonic Processes

Oxidation and hydration as well as formation of carbonates and other salts, like all spontaneous natural processes, are essentially exergonic. Some part of the free energy is consumed in all these processes, whereas the entropy of the system increases. Should operation of the system consist wholly of exergonic processes, the intrinsic energy of the system would sooner or later be exhausted, and further operation would become impossible. Soil systems, however, have been active throughout geological history. We know of no traces of the beginning of this activity, nor can we find any symptom of its probable end. Hence, exergonic processes in the soil must be balanced by the reverse endergonic processes which replenish the free energy of the system. In fact, the rate of inflow of fresh energy through endergonic activity determines the possible amount of exergonic performance of the system. So little is known, however, about the thermodynamic properties of the silicates and other rock-forming minerals that the energy balance of soil dynamics cannot be analyzed at the present time.

The best known endergonic process is the enrichment of soil in organic carbon. An essential part of this process—photosynthesis—takes place outside the soil. It is the function of green plants. Photosynthesis by land vegetation consumes about 60 to 70 billion metric tons of CO_2 per year (*11*). The over-all formula (*12*) for this process is:

$$6H_2O + 6CO_2 + 688 \text{ kcal/mole} \rightarrow C_6H_{12}O_6 + 6O_2$$

Thus, photosynthesis on land results in fixation of about 18 billion metric tons of carbon and about 1.7×10^{17} kcal of solar energy per year. On the average it amounts to fixation of about 3.4 milligrams of carbon and about 33 calories per square centimeter, per year. Eventually the organic material holding this carbon and energy is turned over to the soil, where carbon undergoes oxidation back to CO_2 and energy is released.

Another endergonic process is the comminution of solids. At present this process can be described only in qualitative terms, because of the lack of information about its scope. As a general rule, breaking of a chemical bond requires application of energy, which is absorbed by the products of the process. The sum of the free energies of disunited ions is greater than the free energy of a molecule which has been made of these ions. The sum of the surface energies of fragments of a crystal is greater than the surface energy of an unbroken crystal. Virtually nothing is known about the rate of energizing soils by this process.

Steady State of Soil System

Under the obvious influence of the philosophy of biological sciences, soil scientists have conceived of the soil as an "independent" natural body, and this body—very vaguely, if at all, defined—has been endowed with certain attributes peculiar to organisms (*13*). One such attribute is the faculty of growth and of aging from youth to maturity to ultimate senility. Some rather allegoric statements of the pioneers of soil science, such as Dokuchaev's dictum that "soil, like any other plant or animal organism, eternally lives and changes, now progressively and then regressively" (*14*), have been taken literally and have been uncritically elaborated into the untenable theory of metaphysical soil "ages."

Every thermodynamic system tends toward equilibrium with its surroundings, and such a condition might be approached very closely if the surroundings remain constant long enough. This tendency toward equilibrium is an inevitable consequence of the law of mass action. The term *equilibrium* may be somewhat confusing because of insufficient appreciation of the difference between dynamic and static equilibria. Dynamic equilibrium is the state at which the forward and the reverse processes do not cancel one another but operate simultaneously at equal rates (*15*). In such a state a new molecule is formed at some point of the system for every similar molecule annihilated at the same time at some other point, so the concentration of these molecules or substances in the system does not change in spite of continu-

ous creation and destruction of these particular molecules or substances. The best illustration of dynamic equilibrium is the reversible process or a cyclic series of consecutive reactions. Both of these are possible only under the conditions that exist when extraneous energy is steadily applied to the system.

Physical and chemical processes in soils collectively represent what we call the "pedogenic process." This process itself is not cyclic. The dynamic equilibrium, or a steady state of the soil system, is maintained by the broader geochemical cycles, in which the pedogenic process makes up only a short segment. Thus, the pedogenic process might be likened to the section of an aggraded stream between two bends. Continuously some water is discharged beyond the downstream bend, and simultaneously the same amount of water flows from beyond the upstream bend. Nothing is lost or gained between the bends, but water runs steadily and performs some steady work. Time and time again we may come to the bank to observe the same pattern of ripples or hear the same warbling of a rapid, although the water is never the same. The steady state of a stream between two bends is maintained by a galaxy of factors, including steady evaporation of water by solar energy, distribution of water vapor by winds, condensation of this vapor, and a steady rainfall over the headwater region. All this takes place outside the channel and the area traversed by the stream, but all these factors collectively serve to maintain a steady performance of the stream. Naturally, the steadiness of stream activity lasts only as long as the base of erosion, the gradient of the stream, the sources of water, and other conditions remain constant.

The corresponding "stream" in the pedogenic process is the stream of ions of various elements and energy. The migration of carbon atoms is understood somewhat better and in greater detail than the movement of other elements. Hence, a brief review of the behavior of carbon in the pedogenic process might illustrate the point.

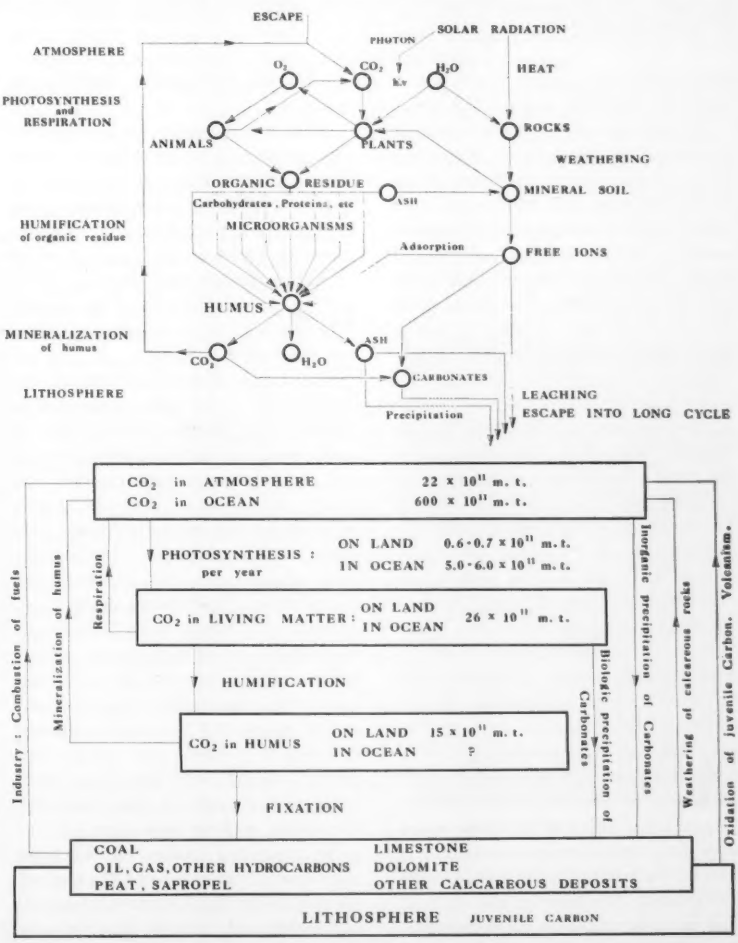
Migration of Carbon

An enrichment of the initial material in carbon is a conspicuous feature of soil formation. The average content of carbon in igneous rocks is about 0.1 percent (*1*), whereas the content of organic carbon alone in some grassland soils is well above 5 percent (*16*). Usually this enrichment is referred to as accumulation of organic carbon. The term *accumulation* is rather misleading. Actual accumulation takes place only at the beginning of the process; the rate of accumulation gradually dwindles to the vanishing point as the system approaches equilibrium. Thereafter the content of carbon remains constant as long as the steady state is not disturbed.

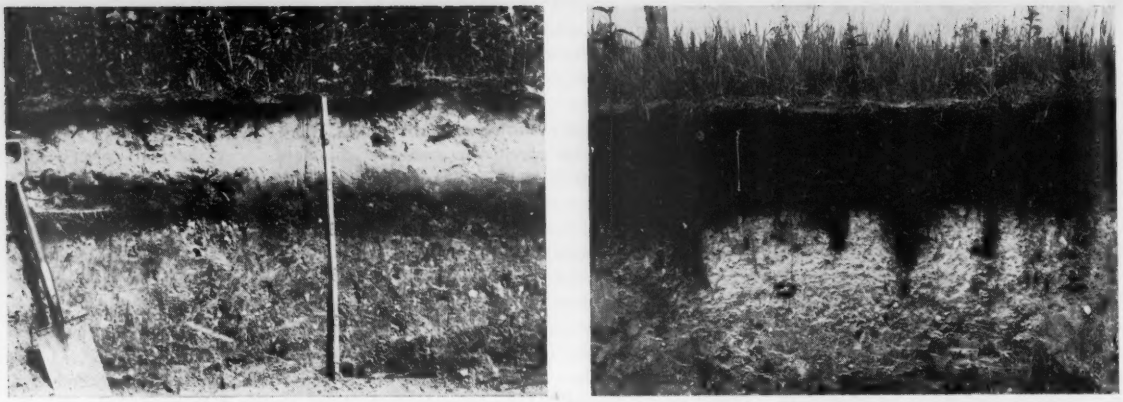
It has been pointed out already that photosynthesis by land vegetation fixes, on the average, about 3.4 milligrams of carbon per square centimeter per year. Life on earth changes its morphological aspect, but its volume, presumably, is a geochemical constant (*17*), determined by such factors as the concentration of CO_2 in the atmosphere and the ocean, the intensity and distribution of solar radiation, the rate of release of essential elements by chemical weathering, and the availability of water. Thus, carbon does not accumulate in living matter. Assimilation of free carbon by photosynthesis is more or less balanced by oxidation of organic carbon.

The detailed balance sheet for carbon cannot be discussed here. Nor can we discuss any movements of carbon atoms other than pedogenic. For our purposes it is enough to point out that an amount of carbon, equal to the mass of carbon assimilated by photosynthesis less the amount of this element released by respiration of organisms [about 15 percent of the value for photosynthesis (*11*)], is turned over to the soil in the residue of dead organisms. In the soil this residue undergoes mineralization or gradually breaks down into the simplest end products, such as water, carbon dioxide, ammonia, and some simple salts.

Fresh organic residue consists of dif-



Geochemical cycles of carbon. (Top) Short cycles; (bottom) long cycles. Estimates of the amounts of CO_2 in long cycles are based on data suggested by Vernadskiy (see *17*), Clarke, Fersman, Noddack, Wickman, Goldschmidt, Mason, and others. Their purpose is merely to give some idea about the probable order of magnitude.



(Left) Profile of a podzol, a forest soil of the humid temperate belt. The light band near the surface of the soil is the bleached "eluvial" horizon, in which all relatively unstable primary minerals, including feldspars and ferromagnesian minerals, undergo drastic decomposition. Virtually all products of decomposition are washed out by rain water, so the bulk of this horizon consists of finely crushed crystals of quartz. The outermost part of the horizon is marked by dark soil humus; beneath the bleached zone is the dark "illuvial" horizon in which the products of decay of primary minerals may be partly recombined into the secondary clay minerals. (Right) Profile of a chernozem, a typical grassland soil. The dark upper horizon of this soil is the zone of enrichment in organic carbon. Beneath it is the zone of local concentration of free carbonates, largely $CaCO_3$. Concentration of carbon in the upper horizon, the thickness of this horizon, the depth at which free carbonates begin to precipitate, and the content of "mineral" carbon in the second horizon are among the principal chemical and physical coefficients which, collectively, define the equilibrium constant of this soil, adjusted to its physical and biological environment.

ferent substances: carbohydrates such as cellulose and lignin, proteins, fats, resins, waxes, and so on (*18*). Some substances decompose readily and in a short time. Some others are more stable and persist for several years. Still others survive for many years. Decomposition of organic residue is the work of soil microorganisms which scavenge organic residue but build their own bodies. They break down the protein of old residue, including their own dead, and synthesize new protein in their bodies. Thus, mineralization of the yearly installment of fresh residue takes more than a year—under certain conditions, even many years—and each year a new installment is added to what has been left from the preceding years. Theoretically, at the beginning of the process some accumulation of organic matter, and hence some increase in the concentration of carbon in the soil, must take place. The number of carbon atoms undergoing oxidation, however, must increase with the increase in concentration of these atoms in the system, so that sooner or later a condition is reached in which the number of carbon atoms being oxidized or otherwise inactivated equals the number of new active atoms of this element being added to the system at the same time. When such a condition is reached, the system reaches a steady state and remains thereafter in this state as long as its surroundings do not change. An essential characteristic of this state is that the composition of the system does not change, whereas its mobile compounds are subject to steady replacement, atom for atom or molecule for molecule.

Oxidation of organic carbon does not compensate for the assimilation of carbon by photosynthesis. A certain part of organic carbon escapes oxidation, being deflected into the channels of long geochemical cycles in the course of which various carboniferous deposits (peat, coal, petroleum, and so on) are formed. The discussion of these cycles is beyond the scope of this article.

Enrichment of the soil in organic carbon does not cover other movements of carbon atoms. Photosynthesis is not the only means of entry of carbon into the soil. It has been pointed out already that a fairly large amount of dissolved CO_2 is brought to the soil by rain water. Another undetermined but undoubtedly large quantity of carbon is released by the solution of limestones and other calcareous rocks. Again, not all carbon dioxide produced by oxidation of organic carbon escapes into the air. A certain part of it is dissolved in the soil water.

The dissolved CO_2—more correctly, free ions of carbonic acids (CO_3^{--} and HCO_3^-)—reacts with free bases, especially the hydroxides of alkalis and alkaline earths, to form carbonates.

As mentioned earlier, at the point where there is an excess of CO_2, the carbonates change into the more soluble bicarbonates and may be leached out. Hence, carbonates remain in the system only if their rate of solution is lower than their rate of formation. These rates refer to the number of molecules that are broken down and the number of similar molecules that are formed anew in a given time. Here, again, at the beginning of the process an accumulation of carbonates takes place; but the rate of such an accumulation decreases exponentially until the steady state is reached, at which time the content of carbonates becomes stabilized, due to the compensation for solution and leaching provided by the formation of new molecules.

The concentration of the mobile compound in the system which has reached a steady state depends upon the ratio between the rates of formation and annihilation of this particular substance. The wider this ratio, the higher the concentration of the compound in question.

The ratio between the rates of formation and annihilation, or the rate of capture of free ions by the system and the rate of escape of similar ions from the system, may or may not be uniform throughout the system. The rate of annihilation or escape may be high enough to prevent any accumulation in one part of the system but may drop below the rate of formation to make accumulation possible in another part. Thus, not only the presence or absence but also the concentration of mobile compounds and their distribution throughout the system depend upon the basic ratios between their rates of formation and destruction.

According to the old concepts, which still have a wide circulation, the soils are subject to aging, and therefore concentrations of mobile compounds in the system either increase or decrease with

passing time and the specific parts of the system harboring these compounds either expand or shrink. These somewhat naive ideas are merely a sort of persistent resonance of the philosophy of biological sciences which influenced the pioneers in soil science.

Soil Profile

The migration of carbon is sketched here merely as an example of the general trend of the migration of elements through the soil. Atoms of oxygen, nitrogen, calcium, magnesium, potassium, sodium, iron, sulfur, phosphorus, manganese, and other elements pass in endless procession along similar courses. Some of them come from the air or the ocean; others are released by weathering from the primary minerals. Ions which escape from the soil may disseminate through space, be carried to the ocean, or sink into the zone of anamorphism. Soil science is not concerned with where they come from or where they go after leaving the pedogenic part of the cycle. The destiny of these atoms outside the soil is beyond the scope of this discipline, which is oriented toward counting these atoms and watching their performance on one particular and short stretch of their route.

The soil serves as a sort of turnstile through which pass endless swarms of atoms of excited matter. Most of these atoms participate in a series of consecutive reactions en route. Individual reactions are more or less localized; some of them take place near the surface, others at one or another depth. Thus, organic carbon is oxidized predominantly in the outermost part of the soil, whereas free carbonates precipitate largely (though not exclusively) at some depth.

Each reaction imparts to the initial material certain new characteristics. To begin with, the products of various reactions are concentrated in different parts of the system; hence these parts, enriched in different elements or compounds, acquire individual composition, structure, consistence, and perhaps color.

Not all such alterations of the initial material are caused by chemical reactions. Some of them are effected by mechanical processes, such as shifting and rearrangement of finely subdivided substances by percolating water inside the soil or, on the surface, by runoff, wind, ice, or other agencies.

Every process or reaction is accompanied by a certain change in the energy content of the reactants and of the products. Various reactions require a different activation energy, which serves as a sort of trigger. Some processes are endergonic, whereas others are exergonic. Hence, each individual part of the system is characterized by its own energy requirement and energy balance. In some parts, potential energy is stored; in others, energy is unlocked.

Localization of different forms of activity and the differential alteration of the initial material by these forms of activity render the soil somewhat layerated, imparting to it a conspicuous profile. The term *profile* calls to mind a certain curve, and this is exactly what a graphic reconstruction of the soil profile is.

A maximum intensity of any property of the soil is at some particular level of the system. Away from this level, the intensity of this property dwindles to the vanishing point. Now, if the soil is cut into slices, if the value of a given property is determined for each slice separately, and if the results are plotted on a diagram against the depth, then we obtain a curve representing the soil profile with respect to this particular property. A combination of curves showing profiles of all essential properties of the soil makes up a graphic reconstruction of the whole soil profile.

A soil profile shows the paragenetic system of individual soil horizons. In a purely formalistic way, a soil horizon is defined as a layer of soil, roughly parallel to the land surface, which differs from the other layers of the same soil in one or several determining characteristics, such as color, composition, and consistence. The essence of genetic soil horizons, however, lies in the functions which they perform rather than in their morphology. Individual soil horizons are the working aggregates of a complex thermodynamic system. With respect to their relationships to the whole system, they might be likened to the organs in a living body, each of which is adapted for the performance of some specific functions. Continuous performance of its specific functions imparts to each horizon its individual chemical and morphological character.

The uppermost soil horizon usually is enriched in organic carbon. One of the essential functions of this horizon is oxidation of organic carbon to CO_2, a process referred to sometimes as "soil respiration." Oxidation of carbon is accompanied by release of stored vadose energy, which is another conspicuous function of this horizon. Decomposition of organic residue in this horizon is brought about by the soil microorganisms which produce various enzymes. Enzymes are powerful catalyzers which accelerate chemical decomposition of minerals and release of free ions. Thus, production of enzymes is the third important function of the upper soil horizon. Another horizon might be adapted for a particularly effective hydrolysis of certain aluminosilicates and production of clay minerals. Still another horizon is adapted for precipitation of carbonates. These are just a few examples of specific functions of individual soil horizons.

Legend about Soil Evolution

Every thermodynamic system in equilibrium with the surroundings reacts to changes in the surroundings in such a way as to free itself of stresses caused by these changes (Le Châtelier, *19*). The relief of internal stresses is achieved by the shift of equilibrium from one level to another with a corresponding change in equilibrium constant.

The surroundings which determine the steady state of the soil are a local combination of the climate, the land form, the biological pressure, and the initial material. These four determinants are

Profile of the soil of arid regions, showing a conspicuous prismatic (dark) horizon which might indicate "solonization" of the soil. Some physical and chemical properties of such soils render the latter unproductive for plants. Amelioration of these soils is difficult and costly. Usually such soils do not occupy large continuous areas but occur in small spots, scattered throughout the land, occupied by nonsolonized or weakly solonized soil.

recognized as the essential factors of soil formation. Maintenance of the steady state of the soil requires that these factors remain more or less constant. Their constancy is not absolute, indeed. To begin with, the intensity of irradiation of the land is subject to daily and seasonal fluctuations due to the earth's rotation on its axis and revolution about the sun. Hence, vadose energy comes to the soil in daily and annual waves which cause the steady state of the system to oscillate about a certain mean position. In addition to these more or less rhythmic vibrations of the steady state, some erratic deviations from the mean, representing a degree of imperfection of nature, also disturb the steady state. These sporadic deviations are caused by yearly differences in amount and distribution of rainfall, in mean temperature, in cloudiness, and so on. Presumably, these relatively small disturbances of the steady state, erratic as well as regular, do not leave any residual and cumulative effects, and after each disturbance the system returns to the same ground state.

The lasting and more profound changes in soils are caused by environmental changes of a different kind—for example, the climatic changes in the Pleistocene. Such changes could not take place without being accompanied by equally great changes in vegetation and in the character and the rates of erosion and sedimentation. These interdependent changes in all determinants of the soil's steady state necessitate a simultaneous adjustment of the soil to the new conditions. If changes in the environment are slow enough, then readjustment of the soil proceeds hand in hand with them, and at no time is the soil out of equilibrium with the surroundings. Catastrophic changes, however, might leave the soil temporarily out of balance, and reestablishment of balance requires a certain amount of time.

The ability of the soil to readjust itself to the changing environment was recognized by the pioneers in soil science, who established several cases of striking changes in the character of soils and concluded that soils are capable of evolutional development. Ideas about soil evolution proved to be quite popular, although they are clearly an outgrowth of the influence of the same philosophy of the biological sciences which was mentioned above. Followers of this school postulate that time is the fifth essential determinant of soil formation and that the character of soil changes merely with the passing of time, even if all other determinants remain constant (*20*). The offspring of this postulate is the theory of soil ontogeny and ages, such as youth, maturity, and senility.

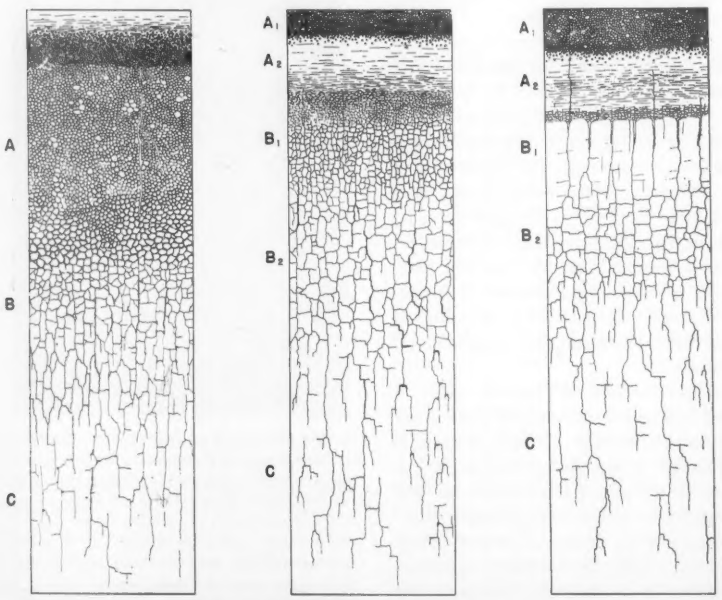
Equilibrium constants of soils in a steady state vary from place to place with local conditions. These soils differ from one another in some chemical as well as morphological characteristics. The differences might be in kind or only in degree—that is, qualitative or quantitative. A certain horizon might be present in one place and absent in another. Again, the same horizon might be, perhaps, twice as thick in one place as it is in another, and better developed. All such differences are due to some differences in local conditions. Notwithstanding these differences, each of these soils might be in a steady state, adjusted at every point to its specific environment. To interpret these local variations as representing different stages of soil ontogeny is hardly anything more than wishful thinking.

Time and space are elements of the essence of being but not factors in any particular form of being. Every material object occupies a certain space, but its existence is not caused by the space. Every change takes a certain time, but, again, it is not caused by mere passing of time.

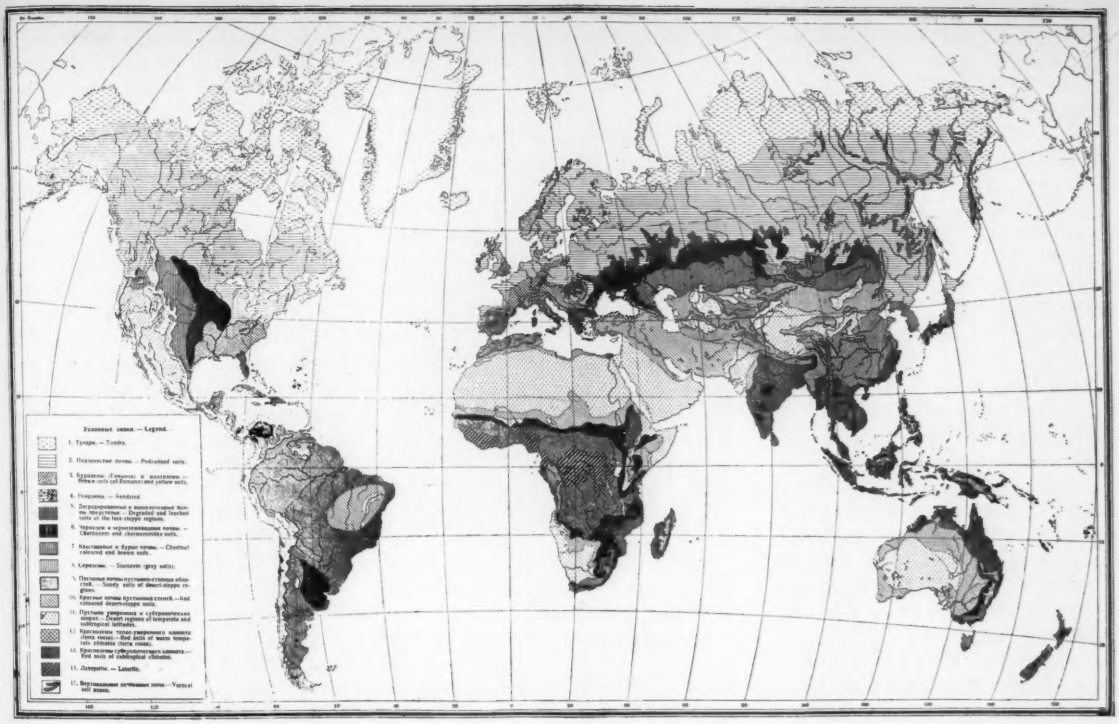
Dependence of soil upon the environment is so complete that evolutional development of the soil would be possible only in unison with a similar development of the determinants of soil formation. As pointed out earlier, the environmental factors are not fixed, indeed. Their changes, however, are of a different kind (*21*).

Changes in climate do not lead to the development of some new types of climate which did not exist before. These changes consist especially of changes in mean temperature and rainfall in certain regions. There is no indication that there have been significant changes in solar constant during geological history. Hence, probably there have been no significant changes in the amount of evaporation from the earth's surface and the total rainfall on earth. Distribution of this precipitation over the earth's surface, however, is not fixed. Geographical distribution of cold and warm climates apparently also is changeable, even though perhaps not within such wide limits as the distribution of dry and humid climates.

The same holds true about land forms. Periods of accelerated mountain formations alternated with periods of peneplanation. A formerly mountainous land could have been leveled in one period, whereas mountains would rise on what used to be a plain, if not the sea bottom, in another period. But whenever mountains or plains have been formed, they have been just ordinary mountains or plains. There is no indication of the development of some peculiar, entirely new, land forms which did not exist in earlier periods.



Typical "structural" profiles of three different soil types. (Left) a chernozem; (middle) a podzol; (right) a solonized soil.



Glinka's world soil map, a scheme of the global soil system (showing zonation of soils) which was discovered by V. V. Dokuchaev at the close of the last century. The northernmost zone is occupied by the primitive tundra soils. The next broad zone is the kingdom of podzolized soils, the most highly developed local form of which is the podzol. The third principal zone is occupied by the chernozems and closely related chestnut soils, followed by the boorozems of the subarid zone; this zone, in turn, grades into the desert zone. In the lower latitudes on both sides of the equator, all horizontal soil zones are distorted and partly eliminated by vertical zonation caused by relief. Each soil zone is characterized by a different equilibrium constant of its soil, corresponding in each belt to the zonal intensity of radiation, rainfall, and biological pressure. The map was published by Prassolov after Glinka's death, in *Priroda* (1928).

The same minerals and rocks have been attacked by the same physical and chemical agencies and altered in the same ways to yield the same products throughout most of geological history. Old clays and sand, no matter when they were formed, do not differ from clay and sand being formed now. Erosion, whenever it has occurred, results in the same sorting of loose rock waste and deposition of sediments. Again, there are no traces of the development of some new mineral or new kind of material.

Thus, changes in climate, land forms, and source materials are essentially changes in distribution over the earth's surface of certain types or kinds of these components of geographical landscapes. These changes cause readjustment of local soils to the different conditions, and thus redistribution of various soils over the land, but they cannnot stimulate an evolutional development of new soil species.

Only in the biosphere do we see a remarkable train of changes with time. These changes have been confined especially to forms of life. Probably there were no great changes in the amount of life. Living matter has a seemingly insatiable urge for expansion and probably has saturated the geophysical sphere fitted for life from the beginning of its existence. Nor have there been any radical changes in the basic composition of living matter. The protoplasm of the amoeba does not differ from the protoplasm in the cells of the higher organisms.

The true causes of biological evolution still are unknown. Perhaps this process is driven onward by some powerful intrinsic impulses of living matter, rather than by external influences. This subject is beyond the scope of this article. We consider living matter in terms of its mass, its chemical composition, its energy, and its rate of renovation rather than in terms of morphology and individual organisms.

Biological pressure (*22*) is an essential factor of soil formation. Changes in this pressure, caused by changes in the density of generic composition of vegetation and other organisms, do disturb the steady state of the supporting soil and cause its readjustment. The latter, however, is merely a manifestation of the natural law (Le Châtelier, *19*), rather than an evolutional process, even if it has been triggered by the evolutional change of its immediate cause.

Soil and Life

The soil is spoken of as a sort of bridge between the organic and mineral worlds (*23*). This bridge carries a two-way traffic. Plants obtain from the soil the essential elements without which the organic world would not exist, whereas organic residue returns the borrowed elements and brings, in addition, other elements, notably carbon and oxygen, to enrich the mineral framework of the soil. In this way some ions of calcium, potassium, magnesium, phosphorus, sulfur, and other elements temporarily withdraw from the pedogenic process, being captured by living matter.

The mass of living matter on land is of the order of magnitude of $n \times 10^{12}$ metric tons, where n is hardly more than 2 (*24*). The bulk of it is made

of nonlithophilic elements—oxygen, carbon, hydrogen, and nitrogen—and consists largely of vegetable matter. Not less than 80 percent of it is water. The "dry matter" makes up, on the average, from 20 to 25 percent of the bulk, and not less than four-fifths of it is carbon and oxygen (*25*). The "essential elements"—largely calcium and potassium—make up about 2 percent of the "green" mass, or from 6 to about 15 percent of the dry matter. Thus, living matter on land holds, at any time, some 3 to 4×10^{10} metric tons of essential elements withdrawn from the soil.

The average life of living matter cannot be accurately estimated. Some organisms, such as *Sequoia sempervirens* or *Sequoia gigantea,* live more than a thousand years, but many others live less than a day. To judge by the rate of photosynthesis, the turnover of living matter on land amounts to about 4.0×10^{11} metric tons per year (on the assumption that about 15 percent of the CO_2 fixed by photosynthesis is returned to the air by respiration (*11*). This amount of old residue must be mineralized and replaced by fresh residue, so the same amount of living matter must die off, to be replaced by the newly formed proteins, carbohydrates, and so on. This replacement requires a passing through the living matter of about 10 billion metric tons of essential elements each year. On the average, for the entire land area, it represents the movement of about 6.6 milligrams of free ions per square centimeter per year.

Movements of essential elements, however, represent only a small part of the exchange between the soil and living matter. The figures given above do not include mobile carbon and oxygen, the combined mass of which is many times greater than the mass of all essential elements combined. Furthermore, living matter keeps in motion an enormous amount of water. In order to build 1 ton of dry matter, plants transpire more than 200 tons of water. Photosynthesis on land amounts to a production of about 4.0×10^{11} metric tons of vegetable material, and about one-fourth of it is dry matter. Production of this material requires transpiration by plants of at least 2×10^{13} metric tons of water, representing from 17 to 20 percent of the annual rainfall on land. These figures are not precise, indeed. Their purpose is merely to give some idea about the order of magnitude of the movements of matter between soil and living matter.

The mechanism of the transfer of free ions from the soil to living matter is not yet fully understood. In a much simplified way it might be described as follows: The soil is filled with a network of thin rootlets, the absorptive region of which is covered by the root hair or tubular outgrowths of the external wall of epidermal cells (*26*). Each root hair (not to be confused with hair root) is a sort of sac made of the membrane, permeable to free ions but impermeable to colloids. Inside the sac are protoplasm and sap, whereas outside it is the soil solution containing ions of elements set free by weathering. In accordance with osmotic pressure, Donnan equilibrium, and various other factors, free ions migrate across the septum inside the root, to be absorbed by colloid and carried by the sap into the aerial parts of the plant. Thus, the equilibrium between concentrations of free ions inside and outside the root hairs is continuously disturbed as long as the plant grows and migration of free ions from the soil into living matter continues.

Mineralization of the organic residue returns all material abstracted from the soil and closes the so-called short or "biological" pedogenic cycles. The term *cycle* does not indicate that the same ions shuttle back and forth between soil and living matter. It means merely that certain quantities of ions are always on the move along this route. Individual ions continuously escape from the stream, but the vacancies are filled just as steadily by other ions of the same elements captured by the current.

The driving force of this never-ending migration is living matter. In this way living matter counteracts weathering. It has been pointed out elsewhere that the general trend of weathering is toward ionic dispersion of solid matter. Chemical denudation of the horizon of weathering tends to leach out from this horizon everything that might be carried away either in solution or in suspension. Living matter intercepts some of the mobile ions, incorporates them into organic tissues, and thus protects against leaching or dissemination in space.

The role of living matter in the geochemical process on the surface of the earth's crust is not restricted to the short pedogenic cycles. Large quantities of free ions are steadily removed from the horizon of weathering by chemical denudation. Clarke has estimated that all rivers carry into the ocean about 2735 million metric tons of dissolved matter per year, especially ions of CO_3, SO_4, and Ca (*1*). The area that is drained into the sea makes up about three-fourths of the whole land area. The remaining one-fourth of the land is drained into closed basins. Assuming that the rate of leaching of this part of the land is similar to that of the land drained into the sea, we may estimate that percolating water removes from the land at least 3½ billion metric tons of dissolved matter annually. This amount alone would indicate an average rate of leaching (for the entire land area) high enough to remove from 2 to 2.3 milligrams of soluble compounds per square centimeter per year. Not all dissolved material, however, reaches the sea. A certain part of it sinks into the zone of anamorphism and precipitates there, so the actual rate of leaching of the horizon of weathering might be somewhat higher than the figure given above.

The migration of free ions from the horizon of weathering into the ocean, into closed basins, or into the deeper layers of the earth's crust is a part of the long geochemical cycles. Information about these cycles is much more fragmentary and sketchy than that about the short cycles. It might be mentioned in passing that living matter, the greater part of which is in the ocean, has a hardly less active role in the long cycles than it has in the short cycles. This activity and its results, however, are outside the scope of soil science, which is concerned with only one link in the long cycles—that is, removal of free ions from the horizon of weathering.

Although the actual average rate of leaching of the horizon of weathering cannot be estimated with any degree of reliability at the present time, it seems fairly certain that, in short pedogenic cycles, living matter on the land keeps a quantity of mobile compounds greater than the amounts of annual loss due to leaching of these compounds. This is an essential feature of soil formation. Usually it is referred to as the accumulation of essential elements in the soil or the development of an essential (from the agronomical viewpoint) property of the soil, its productivity.

Here again the terms *accumulation* and *development* are misleading. A progressive development or accumulation could take place before a steady state is reached. After this, there might be some changes in this state of the system due to adequate changes in the environments, but there would be no further "accumulation."

The concentrations of the mobile compounds in any part of the spatial soil system are determined chiefly by the requirement of the local plant community or—to put it in a more general way—

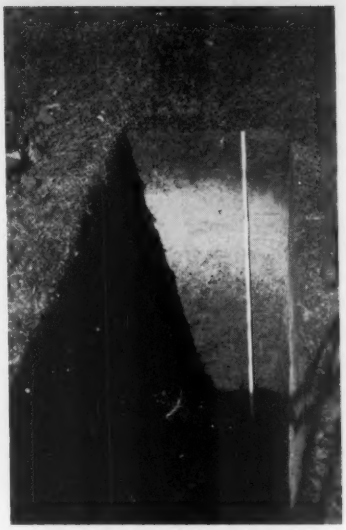
by the local biological pressure. Everything in excess of this requirement is likely to be leached. It might or might not be removed from the soil right away, depending upon the available means of transportation. In arid climates, for example, the rate of leaching might be too low to cope with the liberation of free ions by weathering; hence, some enrichment of the zone of weathering in these ions would result independently of, and sometimes even to the detriment of, local life. Such an enrichment does not go unchecked indefinitely. Again, its rate decreases exponentially until the steady state has been established.

Relationships between soil and living matter are mutual. Living matter maintains a fairly constant concentration of certain elements, the free ions of which would be leached out if there were no life. On the other hand, the biological pressure at any particular place is determined by certain local factors, among which the rate of release of essential elements in available form is one of the most important.

Close interdependence between the soil and living matter has led to the theoretical assumption that soil formation begins with the introduction of life into the process of weathering and, thus, to differentiation between abiotic weathering and soil formation proper. This differentiation is rather academic. The very idea of abiotic weathering is quite vague and perhaps rather groundless, inasmuch as the origin of life on earth is still a mystery (*27*).

All essential determinants of soil formation vary from place to place, and nowhere is any one of them quite uniform over a very large area. Thus, the soil might be in the steady state at various particular points, yet this state would not be the same under different local conditions. Soil taxonomists use these local differences in the general character of the soil as criteria for differentiation between individual soil species, although the very concept of soil species is vague. Perhaps this concept is just another example of the influence of the biological sciences.

Local differences indicate that soil formation involves not merely a differentiation of genetic horizons, giving to the soil a certain morphological profile, but also differentiation in a horizontal plane, which makes the soil a patterned spacial system. Dissection of this system on the basis of ill-defined and wholly abstract soil species might serve some practical purposes but has no scientific basis or justification.



A soil pit. Investigation of soil anatomy requires transection of the soil; this should be regarded as a sort of surgical operation. One carefully and properly made transection provides more information about the make-up of the soil system than scores of amateurish holes hastily made in routine soil survey. The sorry state of genetic soil classification is due especially to the lack of precise information about the object of classification.

Soil science is passing through a difficult stage in its development. After a promising start at the end of the last century and the beginning of the present one, it has been plagued by formalism and has lost much of the original impetus. The aftermath of the two world wars and widespread social upheavals put severe stresses on world agriculture, and soil science, which is still oriented toward agronomy, was called on to concentrate on purely practical problems dealing with the betterment of crops. Research in basic science was forced to surrender priority to sheer technology and soon found itself in the strait jacket of bureaucratic supervision, and its methods of scientific inquiry were largely replaced by sadly unimaginative empiricism.

The same stresses of the last few decades generated an almost explosive surge of other sciences, notably physics and chemistry, which almost overnight outgrew their classical realms and began to deal with the cosmos.

For the time being, agronomy is left far behind, but, indeed, it cannot stay behind too long. The growing population demands more of the essentials of life, and the time is rapidly approaching when our classical agriculture will be unable to cope with the demand.

The prime object of agriculture is to capture solar energy in forms specifically adapted for human consumption—that is, to yield a crop of certain plants, such as cereals, fiber plants, and forage grasses. The amount of energy from the sun's rays which might be captured by plants is determined by the solar constant. By far the greater part of this energy is consumed in maintenance of an environment in which photosynthesis is possible—that is, in evaporating a sufficient amount of water, heating the atmosphere, and keeping weathering on the steady run. Only a precious small part of this energy is available for photosynthesis itself, and this part determines the amount of living matter which corresponds to the saturation of the biosphere by life. Hence, it is not likely that a significant increase in captured energy might be achieved by raising the rate of photosynthesis. It is more likely that future agriculture will have to replace a much greater part of the wild vegetation and low-yielding plants by plants capable of yielding more proteins, starches, fibers, and so on per unit weight of vegetable material. This means rather drastic meddling with the driving force of the short geochemical or pedogenic cycles and might lead to disastrous results if it is undertaken without a thorough understanding of the process.

The soil has been defined rather figuratively as a sort of turnstile through which passes an endless stream of free ions of various elements, making up the short and long geochemical cycles. In its infancy soil science could do little more than stand at the turnstile and observe the morphological effect of the process. Now we can count passing ions and analyze the process quantitatively. In the future we hope to be able not merely to analyze the process but to control it and direct the currents of matter and energy into predetermined channels. An entirely new, man-made mechanism for capturing the energy of the sun's rays will be the contribution of soil science to the age of the mastery of atomic energy and the conquering of outer space.

Conclusion

Current research in basic soil science is somewhat handicapped by the lack of clear-cut differentiation between the problems and aims of the pure and applied branches of this discipline. Applied soil science deals largely, if not exclusively, with the soil-and-plant relation-

ships in their agronomic aspect. Pressing practical problems and the ever-present natural urge for higher standards of agriculture allow the applied branch to dominate the whole realm of soil science. The methods of applied science, however, usually are rather crude and entirely inadequate for a basic research. Therefore, one of the first problems to be solved is that of freeing basic science from the burden of practical tasks. This is not to say that these tasks are unimportant or could be laid aside, but merely to point out that the basic facts, which after all are essential for the quickest and most rational solution of these tasks, might be discovered sooner if research were freed from utilitarian orientation.

Our second problem is to develop an adequate technique. A mere scratching of old cliffs and road cuts for study of soil anatomy or a collecting of samples for chemical analysis served the purpose in the pioneering stage of soil science. It still satisfies the requirement of a routine soil survey, but it is no longer adequate in scientific investigation. Chemical and physical analyses of soil are adequate insofar as procedure is concerned, but methods for interpretation of the results and especially for coordination of various analyses and selection of proper material for laboratory study are in urgent need of radical improvement.

Careful study of soil morphology is an essential prerequisite for the identification of the soil and the collection of samples for analysis. Morphology as such, however, is just an empty shell if its origins are unknown. Hence, the need for a shift of attention in soil study from a descriptive morphology to study of the genesis and dynamics of soils is clearly indicated. Such an orientation of soil science was foreseen by the pioneers (Dokuchaev, Shaler, and others) but later on was overshadowed by practical considerations.

Soil genesis and the pedogenic process still are defined differently by the different schools of soil science. In some schools, the concepts of soils and their functions are still influenced by the theoretical assumptions that soils are somewhat akin to the living bodies and that soil science belongs to the realm of biology rather than to the family of earth sciences. A critical review of these concepts in the light of geochemistry and geophysics is the order of the day.

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John Broadus Watson, Behaviorist

John Broadus Watson, self-styled "the behaviorist," died on 25 September 1958 at the age of 80. His scientific life had come to a close a third of a century earlier, and he was unknown personally to a whole generation of younger men whose field of scientific activity he had defined and vigorously developed. His place in the history of science, and something of his stature, are indicated by three names—Darwin, Lloyd Morgan, and Watson—which represent three critical changes in our conception of behavior.

In establishing the continuity of species Darwin had attributed mental processes to lower organisms. He was supported by a host of anecdotal naturalists who recounted instances of reasoning, sympathy, and even artistic enjoyment on the parts of dogs, cats, elephants, and so on. The inevitable reaction was epitomized in the writings of Lloyd Morgan, who argued that such evidences of mental processes could be explained in other ways. A third step was inevitable, and it was Watson who took it: If there were other explanations of mental processes in lower organisms, why not also in man?

In dispensing with mentalistic explanations of behavior, Watson cleared the way for a scientific analysis. In doing so he acknowledged his debt both to Lloyd Morgan and to Thorndike, who, though he remained a mentalist, supplied a classical alternative explanation of "reasoning" in his experiments on trial-and-error learning. The epistemological issue was also in the air. Watson never took to philosophy (though, as he later said, his "milk teeth were cut on metaphysics"), but it was George Herbert Mead's great personal interest in Watson's animal experiments which supplied an immediate and crucial contact with relevant philosophical issues. A behavioristic interpretation of mental processes was later adopted by operationists and logical positivists, but the issue was to remain primarily empirical rather than logical.

Born in Greenville, South Carolina, Watson was to remember himself as a below-average and troublesome schoolboy with little to show for his early education except a love for manual skills. (He later built a ten-room house with his own hands.) His five years at Furman University, where he received an A.M. instead of an A.B., were aso remembered as a bitter disappointment. But his educational luck suddenly improved when an interest in philosophy took him to the University of Chicago. Few men have made as many fortunate contacts during their graduate careers: with John Dewey (though Watson later complained "I never knew what he was talking about and, unfortunately, still don't"); with Angell (who taught him to write); with Jacques Loeb (whom Angell thought "unsafe" as Watson's thesis advisor); and, particularly, with Mead. Under the Chicago influence his interests turned to biology, and he always regretted that, in addition to his Ph.D., he was not able to finish work for the M.D. degree at Chicago. At the age of 29 he went to Johns Hopkins University as professor of psychology, where he came into even closer contact with biologists and medical men, particularly Jennings and Adolph Meyer. Among psychologists he worked with Knight Dunlap and Robert Yerkes (who were later to formulate their own variety of "psychobiology") and with Curt Richter and Lashley, the latter fresh from Jennings' laboratory.

John Broadus Watson

From all this exceptional stimulation, Watson emerged with a burning recognition of the need for a science of behavior. In 1912, when he first outlined his "behaviorism," there was no scientific discipline devoting itself to this important aspect of nature. Sociologists and economists frequently considered the behavior of men, but seldom of man as an individual. Psychology, in spite of the early American movement of functionalism, was dominated by an introspective "science of mind" which Watson viewed with an impatience which was never to be satisfied. In his most important book, *Psychology from the Standpoint of a Behaviorist,* published in 1919, Watson defined the field he wanted to see studied and assembled available techniques and facts. A second edition in 1924 contained a clearer and bolder programmatic statement. The emphasis was necessarily on the program, for not more than one-third of even the 1924 edition contained facts strictly relevant to the science of behavior the author was proposing. Anatomical and physiological material were used to complete the book. Watson's own contributions were not great, and he was to have no opportunity to extend them. His studies on maze behavior and his concept of "habit" made an uneasy marriage with Pavlov's principle of conditioning, then just beginning to attract attention in this country. His frequency theory of learning was short-lived.

In spite of its shortcomings the book had a tremendous effect. The new movement immediately attracted attention and adherents. Dissenters fell into line on the other side. In the controversy which followed, Watson's taste for, and skill in, polemics led him into extreme positions from which he never escaped. He could not content himself with prosecuting an empirical study of behavior simply as such, for he believed that psychology was the science destined to deal with that subject matter, and he wanted to reform it accordingly. He had another reason for crusading against the strongly entrenched introspectionists, since they claimed to offer direct evidence of the mental processes he wanted to discard. Watson seized upon laryngeal and other covert verbal activities as the "thought processes" of the introspective psychologists and refused to acknowledge sensory aspects of behavior which could also be observed by the behaver himself. It has been suggested that he might not

himself have had visual or auditory imagery. In any case his sweeping denial of the existence of self-observed sensory events (the acknowledgment of which would not, as we now know, have implied the dualism he was so anxious to avoid) occupied him in what he later described as "a continual storm."

The same taste for polemics led him into an extreme environmentalistic position. In *Psychology from the Standpoint of a Behaviorist* he had devoted two chapters to hereditary behavior. Like all those who want to do something about behavior, he had emphasized the possibility of environmental modification, and this was widely misunderstood. Under the stress of battle he was led at last to the well-known cry: "Give me a dozen healthy infants, well-formed, and my own specified world to bring them up in and I'll guarantee to take any one at random and train him to become any type of specialist I might select—doctor, lawyer, artist, merchant-chief, and yes, even beggar-man and thief, regardless of his talents, penchants, tendencies, abilities, vocations, and race of his ancestors. I am going beyond my facts and I admit it, but so have the advocates of the contrary and they have been doing it for many thousands of years."

Watson also went beyond his facts, and in the same crusading spirit, in his views on child training. Experiments on the behavior of infants had shown him that emotional patterns could often be traced to conditioned emotional reflexes (a term he took from Pavlov via Lashley). He thought he saw the seeds of many behavior problems in early home experiences, and in his *Psychological Care of the Infant and Child*—a book he later publicly regretted—he cautioned parents against the unconsidered display of affection. (Current "mother love" theories are the other swing of that pendulum.)

And so it came about that Watson was to be remembered for a long time, by both laymen and psychologists alike, for a too narrow interpretation of self-observation, for an extreme environmentalism, and for a coldly detached theory of child care, no one of which was a necessary part of his original program. His brilliant glimpse of the need for, and the nature and implications of, a science of behavior was all but forgotten. Perhaps history is ready to return a more accurate appraisal. A year before his death he had the satisfaction of dedicating a paperback edition of his popular book *Behaviorism* to the American Psychological Association, which on 7 September 1957 cited him as follows: "To Dr. John B. Watson, whose work has been one of the vital determinants of the form and substance of modern psychology. He initiated a revolution in psychological thought, and his writings have been the point of departure for continuing lines of fruitful research."

B. F. Skinner
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News of Science

Frontal Cloud System Pictures Obtained by Rocket

Clear pictures from the first rocket-camera unit designed specifically to photograph weather frontal systems and their associated cloud formations, from extreme high altitudes over ocean areas where there are no permanent weather stations, have been obtained from a successful firing and recovery of a Project Hugo rocket.

This is the first time that man has been able to look down from so high a vantage point on physical manifestations of the Norwegian weather front theory by which meteorologists have been forecasting the weather for the past 40 years. The frontal cloud pictures are the best obtained to date from a rocket.

The film, recovered at sea from the nose cone of the Nike-Cajun rocket, which reached an altitude of 86.25 miles on 5 December 1958, shows the frontal cloud formations over an Atlantic Ocean area, starting about 200 miles off the Virginia coast and stretching about 700 miles further eastward. The mosaic strip, covering approximately 1000 miles in length, compares roughly with the expanse between the southern tip of Maine and mid-Florida. The launching from the National Aeronautics and Space Agency's Pilotless Aircraft Research Station at Wallops Island, Va., was accomplished from a land-based installation of a shipboard-type Terrier missile launcher, and was effected without any delays or difficulty. Signals emitted by the nose cone's miniature transmitter were easily tracked by one surface ship and one aircraft, each carrying portable radio tracking equipment. Following the flight, the instrumentation package was successfully located and recovered from the sea by the destroyer USS LEARY, despite 8- to 10-foot swells and 25- to 40-knot winds.

Project Hugo

Project Hugo (highly unusual geophysical operations), conducted by the Office of Naval Research with funding assistance from the Bureau of Aeronautics and the U.S. Weather Bureau, is designed to further research into meteorological phenomena in an effort to improve the accuracy of weather predictions. It will also be of assistance to the U.S. Weather Bureau's Hurricane Weather Research Project in the field of hurricane photography.

Instrumentation

The Hugo-Nike-Cajun rocket consisted of a recoverable instrument head attached to a standard Nike-Cajun vehicle. Gross takeoff weight of the assembled rocket was 1552 pounds. Second stage gross weight was 270 pounds. The instrument head contained two 16-millimeter movie cameras, a radar tracking beacon, a Mytymouse homing transmitter, a primary programming device, a secondary programming device, a nose ogive jettison circuit, a drag parachute, a splitring separation system, four blocks of slowly dissolving sea dye marker, and appropriate power supplies.

Design and construction of the Project Hugo rocket-camera assembly was done by the New Mexico State University at Las Cruces, under contract with the Office of Naval Research. The cameras themselves were specially designed and prepared by the Naval Research Laboratory.

Performance

In the 5 December shot the instrument head was not stabilized. The effect of this as it appeared in a showing of the film was a rather rapid turning of the

Three aspects of Project Hugo: (Top) Composite of five photographs shows a frontal cloud formation over the Atlantic Ocean starting about 200 miles offshore and extending about 700 miles further seaward. The mosaic strip covers approximately 1000 miles from Maine to Florida. (Bottom left) Map shows firing point (×) of camera-rocket and some of the area photographed from an altitude of 86 miles. (Bottom right) Nike-Cajun missile on Terrier launcher being checked by technician at National Aeronautics and Space Administration's Wallops Island, Va., station. The instrument canister, containing two cameras, is behind the nose cone.

point of view of the cameras. Of the total running time of the cameras, 220 seconds, only about a third resulted in pictures of the oncoming front. The sun, the falling Cajun carrier, and sections of the Outer Banks of North Carolina were photographed during the largest proportion of the running time. While these sections of the film were of value in calculating the exact position the rocket had had, they do represent a waste of a considerable amount of time. In future shots, the second camera, by the use of a prism, will photograph at a 45 degree angle to the other. This placement, given the limitation of two cameras, will maximize the footage depicting a weather system.

Background

The Wallops Island shot was just one part of a long-term program in the study of clouds and other weather phenomena that could be said to have started about 15 years ago. Various projects, not formally connected, but dealing with the same general problem of weather and prediction have been taken up since the first studies of raindrop formation by Langmuir. Project Cirrus showed that holes could be cut in cirrus clouds by dry ice seeding. Project Scud further examined the possibilities of rain making by this and other methods. The current project relates to these studies in that it offers a means of gaining a synoptic view of a major weather system as it approaches a populated area. This wide view of a system, together with the reports from surface stations and air-borne stations, offer the weather predicters very valuable information which could serve as the basis for highly accurate forecasts.

Efforts to improve forecasting, particularly of hurricanes, were intensified after the destructive hurricanes of 1954, when insured damage amounted to $276 million.

Future Plans

Although future testing of the rocket-camera device will depend on funds available, the naval officer who was in charge of the test, Willard Huston, anticipated the firing of 8 to 10 similar shots during 1959. Because the canister containing the cameras can be recovered and used again in other shots, the cost of the individual shot is that of the Nike-Cajun missile alone, or about $7000.

By virtue of its simplicity and ruggedness, the canister and its vehicle could be kept on hand for an indefinite period at isolated weather stations for use when reports of a threatening storm were received. Personnel with a minimum of

training could fire the missile, recover the cameras, process the films in a few hours, and then report the results to a mainland weather data-processing center where they could be integrated with reports from surface stations.

Nuclear Test Control

On 5 January, the day that the East–West conference on nuclear tests resumed in Geneva, the United States announced that new data indicate that it is more difficult to identify underground explosions than had previously been believed. Immediately the *New York Times* published an article headed "Hopes Lessened for Atomic Curb." On 25 December the *Times* headline on the same subject had read "Test Ban Accord is Seen by Spring."

The text of the U.S. statement follows. It was prepared by the President's Science Advisory Committee with the concurrence of the Department of State, the Department of Defense, and the Atomic Energy Commission. The names of the seismologists responsible for the study that was the basis for this statement were not announced at the time the statement was released by the White House. No details were given.

"Since the Geneva conference of experts last summer, United States seismologists on behalf of the Government have continued to study all available data on the problem of detecting and identifying underground explosions, including new data obtained from the underground tests conducted in Nevada this past October. These studies and new data indicate that it is more difficult to identify underground explosions than had previously been believed.

"The Geneva conference of experts last summer concluded that, although it is not possible to identify an underground explosion by seismic means alone, it is possible to identify a large fraction of seismic events as natural earthquakes when the direction of first motion of the seismic signal is observed at several, appropriately located stations. This procedure reduces the number of seismic events which would be unidentified and could, therefore, be suspected of being underground tests.

"Analysis of all available seismic data on underground tests, including the data new since last summer, has shown that this method of distinguishing earthquakes from explosions is less effective than had been estimated by the Geneva conference of experts. These analyses and new data also indicate that the seismic signals produced by explosions are smaller than had been anticipated and that there are consequently about twice as many natural earthquakes equivalent to an underground explosion of a given field as had been estimated by the Geneva conference of experts.

"These two factors mean that there will be a substantial increase in the number of earthquakes that cannot be distinguished from underground nuclear explosions by seismic means alone. For example, the total number of unidentified seismic events with energy equivalents larger than five kilotons may be increased ten times or more over the number previously estimated for the system recommended by the Geneva conference of experts.

"The effect of this new analysis and data on the capabilities of the system recommended by the Geneva conference of experts, as well as modifications of that system which could restore its originally estimated capability against underground tests, are at present under study by United States scientists.

"The Department of State advises us that the results of this continuing analysis have been communicated to the United Kingdom and the Union of Soviet Socialist Republics delegations at the present Geneva conference on the discontinuance of nuclear weapon tests, and that the United States delegations will be prepared to discuss this information with experts of the other delegations. This will assure that all the parties at the present Geneva conference have available the best scientific information and analysis in their consideration of the problem of detecting and identifying underground tests."

Soviet Solar Rocket

The rocket that the U.S.S.R. launched toward the moon on 2 January passed the moon on 4 January and went into orbit in an elliptical course around the sun on 7 January, according to reports from scientists in the Soviet Union. The Soviet news agency Tass reported that in its first 5 days of flight the rocket, which was moving 621,000 miles ahead of the earth, had traveled approximately 9 million miles from the point in space occupied by the earth at the time the rocket was fired. The earth, speeding along in orbit at 18.6 miles per second, traveled about 8,370,000 miles in the same period.

On 14 January the rocket reached its nearest point to the sun, about 91 million miles, and achieved its maximum speed of approximately 20 miles a second. At the most distant point in its recession from the sun, the vehicle's speed is expected to drop to some 17.34 miles a second. Soviet scientists predict that once every 5 years the rocket may come close enough to the earth to be visible with powerful telescopes.

The new planet is the last stage of a multistage space rocket. The stage weighed approximately 1½ tons without fuel. The combined weight of the instruments, together with the power sources and the container, amounted to 794 pounds. In addition to two radio transmitters, which went dead on 4 January when the rocket was 373,125 miles from the earth, the vehicle carried special equipment designed to produce a sodium cloud—an artificial comet. This comet was formed on 3 January and was visible for several minutes in the constellation Virgo. It was possible to photograph the comet with optical instruments equipped with light filters isolating the sodium line of the spectrum.

Population Genetics at Purdue

Purdue University has announced the establishment of the Population Genetics Institute to coordinate an expanding research program in population genetics. The major objective of the institute will be to investigate the effects of various mating systems under varying environmental conditions. In addition to theoretical studies, problems will be investigated experimentally with laboratory organisms such as *Drosophila*, *Tribolium*, and mice. Heretofore, population genetics work has been carried out in the departments of dairy and poultry science, the Purdue statistical and computing laboratory, the North Central States regional poultry breeding laboratory and the pioneering research laboratory for animal genetics, the Animal Husbandry Research Division, Agricultural Research Service, U.S. Department of Agriculture.

Facilities for the institute in Purdue's new Life Science Building will include offices, fully-equipped laboratories, and three specially designed controlled-climate chambers. The facilities of the statistical and computing laboratory, including a digital computer, will be used for expanding the theoretical or mathematical approach to problems of population genetics.

A. E. Bell, professor of poultry science, has been appointed chairman of the institute. Others from the Purdue staff named to the institute include V. L. Anderson, B. B. Bohren, S. C. King, W. H. Kyle, J. H. Martin, T. G. Martin, and H. E. McKean.

Report on Medical Education

American medical colleges had a record enrollment of 29,473 students in 1957–58. Sixty of the 85 operating medical schools reported major construction, costing $47 million, in the planning, beginning, or completion stages. Forty-nine

schools reported major developments and changes in administrative organization, methods of student selection, curriculum, and financing. An estimated $275 million was spent by the medical schools in 1957–58, an increase of 13 percent over the preceding year.

A total of 6861 physicians was graduated from the 78 approved 4-year schools in 1958, as compared with 6796 in 1957. (There are four 2-year schools of basic medical sciences and three newly developing schools that have provisional AMA approval.) A new record was established in 1957–58 for the number of entering freshmen—8030. The preceding year the number was 8014 and 10 years ago the number was 6487. Further, 1644 women were enrolled in medical school, and 355 were graduated in 1958.

These were among the many facts and figures in the 58th annual report on medical education by the American Medical Association's Council on Medical Education and Hospitals. The 90-page report appeared in a recent issue of the *Journal of the American Medical Association.*

News Briefs

On 9 February 1949, the U.S. Air Force School of Aviation Medicine will commemorate the 10th anniversary of the founding of the department (now division) of space medicine. On 9 February 1949, Major General Harry G. Armstrong, U.S. Air Force (MC), former commandant of the School of Aviation Medicine and a pioneer in aeromedical research, established the department, probably the first of its kind in the world. Armstrong and the four original members of the department will be present for the anniversary gathering, which will include discussions on space medicine and predictions for the next decade.

* * *

Harvard University has announced that five professors will make a 2-week visit to Russia early in February as part of the Soviet–American exchange agreement. They will visit Leningrad University, which will in turn send five professors to Harvard for 2 weeks in late February or early March. The Harvard group includes one scientist, E. Bright Wilson, Jr., Theodore William Richards professor of chemistry.

* * *

The American Institute of Physics has initiated a new service this month by publishing a booklet that lists assistantships and fellowships open to graduate students in physics in 1959–60. Physics department chairmen in institutions offering graduate work in physics report in the booklet the number of graduate assistantships and fellowships available in their departments, the stipends, the tuition payable if not included in the stipend, and the number of hours of service required per week. The booklet may be obtained from the AIP Placement Service, 335 E. 45 St., New York 17, N.Y.

* * *

On 16 January the Engineers Joint Council cited the Westinghouse Educational Foundation and the Carnegie Institute of Technology for pioneering in encouraging young men and women to seek careers in engineering and science. This year observes the completion of 20 years of George Westinghouse Scholarships at Carnegie Institute. Each year since 1938, ten 4-year scholarships have been awarded to secondary school seniors selected from over 1000 applicants per year. The program is one of the earliest in industry-education cooperation.

* * *

The Proceedings of the Royal Institution 21, Albemarle St., London, W.1., will be published three times a year in future instead of annually. The Proceedings contain accounts of the well-known Friday Evening Discourses, and one advantage of the new procedure will be that the Discourses will appear in print soon after their delivery. The Evening Discourses at the Royal Institution were started by Michael Faraday in 1826, and for more than 130 years they have maintained the highest standards of popular exposition. The Proceedings therefore contain authoritative accounts of research and learning, written for the nonspecialist and covering many branches of science and other subjects.

* * *

The Atomic Energy Commission has announced the initial operation of the Special Power Excursion Reactor Test No. 3 (SPERT-III), a versatile research facility developed for studying nuclear reactor safety. Criticality was achieved on 19 December in the new plant, which is situated at the National Reactor Testing Station in Idaho.

* * *

Amherst College has decided to experiment with a plan to give a year's "leave of absence" to students whose academic performance is not commensurate with their ability. A student judged capable of doing A or B work but getting C's could be asked to take a year off to make up his mind about the value of college. He would be allowed to return in good standing. No change is being made in the passing marks required to stay in school. The plan is expected to result in perhaps a dozen leaves of absence a year.

* * *

A Committee on Education has been established by the Society of American Bacteriologists under the chairmanship of L. S. McClung, department of bacteriology, Indiana University. Included in the duties of the committee will be a revision of the society's brochure *A Career in Bacteriology,* investigation of the training in microbiology of teachers of elementary biology, preparation of experiments in microbiology suitable for use in introductory biology classes, and the listing of films in microbiology and of other teaching aids.

* * *

The American Institute of Medical Climatology was organized in Philadelphia in late November. The institute is planning a program of research and education in all phases of the relationship between weather and human life. Twelve sections will implement the work of the institute. Charter members elected George M. Piersol as president; secretary is Igho H. Kornblueh, 1618 Allengrove St., Philadelphia 24, Pa.

* * *

For the first time since 1950, the number of children born in the United States apparently decreased in 1958, according to estimates released by the U.S. Public Health Service. National Office of Vital Statistics records indicate that about 4,248,000 babies were born in 1958, a decline of 53,000, or 1 percent, from the record high set in 1957. Fewer marriages in 1957, when the marriage rate dropped 4 percent from the previous year, account for the estimated decrease.

Scientists in the News

HERBERT F. YORK has been appointed by President Eisenhower to the new position of director of defense research and engineering, Department of Defense. On 15 March 1958 York was appointed director of research, Advanced Research Projects Division of the Institute for Defense Analyses, and chief scientist of the Advanced Research Projects Agency of the Office of the Secretary of Defense. He has served on many governmental advisory committees, including the Air Force Scientific Advisory Board and the Army Scientific Advisory Board. He is a member of the President's Science Advisory Committee.

JAMES G. HILTON, an associate professor of pharmacology at the University of Mississippi Medical Center, has accepted an appointment as an associate professor of pharmacology at Marquette University School of Medicine.

RONALD BELL has joined Greer Hydraulics, Inc., Jamaica, N.Y., as senior research physicist. He will be engaged in research and developmental programs involving servo systems, transistorized circuitry, and other electromechanical devices. He was formerly associated with

the Bell System Westrex Division. Greer Hydraulics is an engineering-manufacturing concern specializing in fluid mechanical components and systems for aeronautics, missiles, and industrial applications.

GUENTHER STOTZKY, formerly research associate in the department of botany, University of Michigan, has joined the United Fruit Company as soil microbiologist at the new Central Research Laboratories, Norwood, Mass.

WILLIAM M. FAIRBANK, now an associate professor at Duke University, will become professor of physics at Stanford University next fall. He is a specialist in low-temperature physics. In recent years he has earned wide recognition for his work on the distinctly different properties of the isotopes helium-3 and helium-4 in their liquid state.

VICTOR HICKS was recently promoted to rear admiral, U.S. Naval Reserve, thereby becoming the first and only engineering duty (ordnance) officer of flag rank, regular Navy or Naval Reserve. Not now on active duty with the Navy, he is in charge of the physics laboratory at the Allen-Bradley Company in Milwaukee, Wis., and research professor of physics on the graduate faculty of Marquette University.

The 80th birthday of KURT GOLDSTEIN, last 6 November, will be celebrated in the spring issue of the *Journal of Individual Psychology*. The special issue will include an autobiographical statement and a group of papers gathered by a committee of friends. The issue will also contain a large portrait of Goldstein and his bibliography from 1936 to 1958. The prepublication price of the Goldstein issue is $1.75. For further information, write to: Journal of Individual Psychology, University of Vermont, Burlington, Vt.

The Albuquerque (N.M.) Nuclear Division of the Kaman Aircraft Corporation has announced the appointment to its senior research staff of FRANK B. GRAY, JR. For many years Gray was head of the applied physics development group of the Leeds and Northrup Company, where he was responsible for the development, design, and initial applications of electronic and optical instrumentation for industrial and military contracts.

Appointment of DONALD M. BROWN as research associate in botany to conduct overseas procurement of exotic plants for potential medicinal purposes has been announced by the College of Medical Evangelists, Loma Linda, Calif. Brown will leave for East Africa soon after 1 February. Purpose of the program, financed by the Sterling-Winthrop Research Institute of Rensselaer, N.Y., is to discover and develop natural products, primarily plants, used as medicines by primitive overseas tribal groups. Brown was professor of botany and chairman of biology at La Sierra College in Arlington, Calif.

WILLIAM C. HOLLAND has been named professor of pharmacology and chairman of the department at the University of Mississippi School of Medicine. He replaces JAMES C. RICE, who retired on 31 December 1958. Holland has been a member of the pharmacology department faculty at Vanderbilt University School of Medicine since 1950.

THOMAS P. NASH, JR., professor of chemistry and dean of the School of Biological Sciences, University of Tennessee Medical Units, has received the 1958 Southern Chemist Award of the American Chemical Society's Memphis Section. He was honored "for distinguished service to the profession of chemistry in the Southern states."

JAMES B. FISK, formerly executive vice president of Bell Telephone Laboratories, has been elected president of the company. He succeeds MERVIN J. KELLY, who has been elected chairman of the board of directors. Kelly has served as president of the Laboratories since 1951. ESTILL I. GREEN, vice president in charge of systems engineering, is the new executive vice president.

HENRY E. BILLINGSLEY has been appointed director of the Office of International Cooperation of the National Aeronautics and Space Administration. He was formerly chief of the Western European Division of the Defense Department's Office of Internal Security Affairs. Billingsley will head an NASA-sponsored program to coordinate U.S. nonmilitary research and development in aeronautical and space matters with similar work of other nations and international organizations. This cooperative program was authorized by the National Aeronautics and Space Act of 1958.

The 1958 Southwest Award of the American Chemical Society was recently presented posthumously to KENNETH A. KOBE, former chairman of the department of chemical engineering in the University of Texas. The prize is given annually by the society's local sections in Oklahoma, Arkansas, Louisiana, Texas, and New Mexico for exceptional achievement by a chemist or chemical engineer. Kobe was cited for his contributions to the development of chemical processes and to chemical engineering education.

Recent Deaths

BENJAMIN F. BAKER, Monroeville, Pa.; 60; engineer with the Westinghouse Electric Corporation for 34 years and holder of 104 patents; taught physics at the University of Pittsburgh before joining Westinghouse; 21 Dec.

ELIZABETH M'QUEEN BANCROFT, Hermosa Beach, Calif.; 80; founder of the Women's International Association of Aeronautics; 25 Dec.

RUSSELL T. CRAWFORD, Berkeley, Calif.; 82; professor emeritus of astronomy at the University of California, Berkeley, who computed the orbits of many astral bodies; 21 Dec.

LINCOLN GODFREY, JR., Philadelphia, Pa.; 43; research director of the National Council of Alcoholism; 19 Dec.

HENRY KRUMB, New York, N.Y.; 83; mining engineer and director of the Newmont Mining Corporation; former vice president of the American Institute of Mining and Metallurgical Engineers; 27 Dec.

FRANCIS LEACH, Silver City, N.M.; 70; mineralogist, technologist and general manager of the Radium Company of Colorado; built a laboratory and pilot plant for the extraction and refining of radium, in partnership with her husband; 24 Dec.

ROBERT MATHESON, Ithaca, N.Y.; 87; professor emeritus of the department of entomology and limnology of Cornell University and a staff member since 1909; author of textbooks; 14 Dec.

WILLIAM E. MOFFITT, Cambridge, Mass.; 33; associate professor of chemistry at Harvard University and a leader in theoretical chemistry; 19 Dec.

ORSON D. MUNN, Southampton, N.Y.; 75; patent lawyer and former editor and publisher of *Scientific American* magazine; 22 Dec.

ELMER M. NELSON, Arlington, Va.; 66; head of the nutrition division of the Food and Drug Administration since 1949, and director of the vitamin division from 1935 to 1949; 25 Dec.

LEON A. ORBELI, Moscow, U.S.S.R.; 77; physiologist and a specialist in military medicine who worked with Ivan Pavlov; secretary of the Soviet Academy of Science's section on biological science until 1948; 12 Dec.

CLARA THOMPSON, New York, N.Y.; 65; founder and executive director of the William Alanson White Institute of Psychiatry; assistant executive director of the Washington School of Psychiatry, 1943–46; coauthor of *Psychoanalysis: Its Evolution and Development*; 20 Dec.

JOHN E. YOUNGER, Hyattsville, Md.; 66; head of the mechanical engineering department at the University of Maryland; taught at the University of California before joining the University of Maryland in 1938; 30 Dec.

Book Reviews

Behavior and Evolution. Anne Roe and George Gaylord Simpson. Yale University Press, New Haven, Conn., 1958. viii + 557 pp. Illus. $10.

This book is a very carefully organized cooperative effort, the result of two conferences organized jointly by the American Psychological Association and the Society for the Study of Evolution. The planning began under the chairmanship of Anne Roe in 1953, and a first conference was held in the spring of 1955. This was primarily for the purpose of exploring the possibility of real interdisciplinary collaboration and communication, and it was successful enough to lead to the holding of a second conference in the following year, organized with the specific purpose of producing a publishable symposium. Drafts of formal papers were circulated in advance to the participants of the second conference; there they were discussed in a manner that was essentially editorial.

The resulting symposium is, as the introduction points out, a mosaic, but, as the introduction goes on to say, "a mosaic is (or can be) a picture and not a casual assortment of tiles." I think most readers will agree that the organizers and editors have in fact been successful in synthesizing a large variety of contributions from different viewpoints into a coherent general scheme. This is a book, and not simply a haphazard collection of individual items.

Both the topics mentioned in the title, behavior and evolution, are of course enormously complex subjects. No single volume can hope to deal exhaustively with either of them, let alone with both simultaneously. For the purpose of a symposium designed to cover, if not all possible aspects of behavior and evolution, at least a wide and representative range of them, it was necessary to select some focal point around which the various contributions would be integrated. This focus is explained in the introduction in the following words: "To demonstrate that morphology, physiology and behaviour are aspects of organisms all inseparably involved in, and explained by, the universal fact of evolution became a principle object of this symposium. . . . Behaviour itself, what it is descriptively and how its different aspects may be explained and interrelated through evolution, is the very heart of the book's theme."

The book starts, therefore, with a general statement of the status of evolutionary theory of the present day. A chapter by Simpson gives a summary account of the modern neo-Mendelian, or "synthetic," theory and sketches the general principles which have emerged from paleontological study, and Colbert and Romer provide some examples, mostly from vertebrates, of the conclusions that can be drawn from comparative and anatomical studies as to the relations between evolutionary morphology and behavior. After this introduction to the basic evolutionary ideas, the second part provides a background for an understanding of the physical basis of behavior. Beach discusses the evolutionary aspects of psychoendocrinology; Caspari and Sperry deal respectively with the genetic and developmental bases of behavior; and Pribram and Bullock discuss the evidence from comparative neurology and neurophysiology.

These two introductory parts bring us to the core of the book, a series of seven chapters entitled "Categories of behaviour." In the first of these, Nissen discusses the various ways in which behavior may be classified: for instance, by its function, such as reproduction and dispersal; by descriptive categories, such as social behavior; or by the kind of mechanisms involved, such as tropisms and conditioning. He concludes by a suggestion that the behavior of any animal could be scored according to its effectiveness in six functional categories (sensory capacities, locomotion, manipulation, perception, sensory motor connections, and reasoning) and advances the hypothesis that if at a series of geological epochs the highest-scoring species at each of these points were taken, we would find evidence for some over-all consistency in the direction of behavioral evolution. This is, of course, to suggest that the evolutionary process does manifest a general direction of change—a concept which has often been referred to as evolutionary "progress," unfashionable though that word may be at this time.

In later chapters of this section, some examples of the various categories suggested by Nissen are discussed in more detail. Marston Bates reviews food-getting behavior, mostly in insects and vertebrates; Carpenter deals with territoriality; while Thompson and Emerson discuss social behavior in general, and the evolution of behavior among social insects. In a very stimulating chapter, Harlow considers the evolution of a behavioral mechanism—namely, learning. He pays more attention than is usual in such discussions to the learning abilities of quite lowly forms such as flat-worms, and he argues forcefully that "there is no evidence that any sharp break ever appeared in the evolutionary development of the learning process."

An article of a rather different kind is that of Hinde and Tinbergen, who discuss the comparative study of species-specific behavior and point out "that the comparative study of behaviour can yield the same type of results as comparative anatomy—a tentative description of the course evolution has taken." They support this by a detailed study of the behavior of certain nearly related species, using the concepts and methods of the "ethology" school. A similar conclusion is reached by Mayr in a chapter entitled "Behaviour and systematics," which deals with the subject from a broader comparative point of view. This leads on to two chapters in which behavior is discussed as a part of the evolutionary mechanisms. Spieth shows that the reproductive isolation between species often involves a behavioral sexual-isolating mechanism, while Pittendrigh discusses behavior as an aspect of adaptation, subject like morphological and physiological adaptations to genetic variation and selection.

This brings us to the penultimate section of the book, on evolution and human behavior. Washburn and Avis begin by a comparative review of the behavior and correlated functional adaptations of monkeys, apes, and man. We then pass on to three fascinating and stimulating chapters in which concepts derived from the theory of evolution are applied to higher human cultural behavior. The subject is approached in turn from a general biological, a psychological, and a cultural anthropological point of view. When it is mentioned that the authors are Julian Huxley, Freedman and Roe, and Margaret Mead, the reader will easily realize that these chapters, short as they are, are packed too full for it to be possible to indicate the nature of their contents in a short review.

The book concludes with an epilog by G. G. Simpson, who makes a manful and indeed remarkably successful attempt to synthesize the enormously varied contributions of the earlier authors. The success of Simpson's epilog is in fact a demonstration of the real unity which the book possesses; it shows that an account can be given of animal behavior, and at least to some extent of human, in

which the theory of evolution provides just as effective an intellectual framework as it can do for a textbook of comparative anatomy.

If a word of criticism were to be offered, it might be this: The relation of the behavior of an animal to the evolutionary process is not solely that of a product; behavior is also one of the factors which determines the magnitude and type of evolutionary pressure to which the animal will be subjected. It is at the same time a producer of evolutionary change as well as a resultant of it, since it is the animal's behavior which to a considerable extent determines the nature of the environment to which it will submit itself and the character of the selective forces with which it will consent to wrestle. The various types of "feedback" or circularity in the relation between an animal and its environment are rather generally neglected in present-day evolutionary theorizing. One might have hoped that the complexity of this relationship would be more explicitly taken into account in a book concerned primarily with behavior and evolution, since it is in relation to behavior that the circular relation is perhaps most obvious. However, although such considerations are perhaps often just below the surface of the problems discussed by the various authors, they never seem to emerge completely into the light of day. For instance, when Pittendrigh writes that his "assigned task in this symposium was to discuss behavior as adaptation," I would have liked to see him go on to state that the adaptation must be to circumstances which arise largely as a result of the behavior. Again, Spieth, in his extremely interesting discussion of the role of behavior in the reproductive isolation between closely related species, never quite gets around to discussing how far the behavior itself has played a role in the production of the differentiation between the species. There is here, I think, waiting to be developed, a synthesis between evolutionary theory and the study of behavior which goes even deeper than that recorded in this symposium.

C. H. WADDINGTON
Institute of Animal Genetics,
University of Edinburgh

Human Dissection. Its drama and struggle. A. M. Lassek. Thomas, Springfield, Ill. 1958. 310 pp. Illus. $6.50.

All scientific men are aware of the effort, the long hours, the frustrations, and often the personal danger involved in the tasks they have chosen to do. Some sections of the public may be interested in scientific things, but other people are at times very resistant toward nontraditional ideas. In two fields—namely, animal experimentation and human dissection—obstructions have developed, not because of the ideas involved, but because of the materials and methods used for investigation and teaching. The history of the use of animals remains to be written; this book, however, does an admirable job with the story of dissection—its impact, the personalities involved, and the emotional milieu at different times and places.

Anatomy, like other academic areas, has immediate concern for only a small but selected minority. Today, for instance, an adequate amount of dissection material for teaching and research would be supplied in most states having medical and dental schools by about one body per 200 deaths. Few places now have even this much material to work with; the whole history of dissection, except perhaps for continental Europe during the 18th and 19th centuries, reflects an inadequate supply.

Lassek has made an interesting and careful compilation of accounts from many sources for this history. It relates to the whole span of anatomical study, from ancient times to 1958. About a third of the book deals with pre-Vesalian anatomy; another third is concerned with dissection in Europe and Asia, while the remainder covers dissection in America. The book shows a broad perspective; the author pictures an age-long struggle between effective pedagogy and the search for knowledge on the one hand and prejudice, noncooperation, and obstruction on the other.

Death is an incomprehensible event. Primitive ideas—spirits, mysticism, fear, ritual—have always had an effect on the manner in which people treat their dead. Lassek properly emphasizes this point. Problems have been most complex in the British Isles and in America, where legal provisions for anatomizing have lagged in relation to the demand for trained medical men. People have been disturbed—this was especially true during the 100-year period from 1775 to 1875—by the activities of "gentlemen" resurrectionists (that is, surgeons and medical students) and by hoodlums who engaged in grave robbing. The methods used, the squabbles with the law, the notorious cases, the murders for profit, and the riots of outraged townsfolk are described in detail. The need for good anatomical laws and the pressures on legislators are outlined.

Lassek also gives enough biographical data on about twenty of the key anatomists of the past 2000 years or so to make one appreciate the drives that motivated these men. He tells of spectacles of the 16th century where the bodies of criminals were dissected and demonstrated before students and "important" people. There are stories also of the surgeon-anatomists of the 18th and 19th centuries and of the improvements in instructional standards in the 20th.

Lassek has not only presented a history; he has laid out the background for the persisting problem of cadaver shortage that also plagues present-day anatomists.

W. T. DEMPSTER
Anatomy Department,
University of Michigan Medical School

Tribes that Slumber. Indian times in the Tennessee region. Thomas M. N. Lewis and Madeline Kneberg. University of Tennessee Press, Knoxville, 1958. xi + 350 pp. Illus. $3.75.

"This book has been written for students, for amateur archaeologists, and for all persons with curiosity about the Indians" (preface, page v.).

The organization and literary style of this book, enhanced by a most attractive binding and beautiful illustrations, set a high standard for popular writing on American archeology. Since this is the first contemporary book in the field to be written by professionals for persons without advanced technical training, it is well that the standards are so high. Certainly American archeology needs more in the way of good publication for this audience, and it is expected that this book will serve, in some degree, as a model.

Chapter headings include "Nomadic hunters of the Ice Age," "The Archaic era," "Early Woodland Indians," and "Burial Mound Builders." The later and more elaborate Dallas, Mouse Creek, and Historic Cherokee cultures, Busk-Southern Cult ceremonialism, and Cherokee ceremonialism and history are well described and made the subjects of generalized interpretative treatment in the other chapters. Ten thousand years of the prehistory and early history of the Tennessee area are covered.

The first two chapters are sufficiently general to be of considerable interest in the eastern United States as a whole. The later chapters describe and interpret phenomena restricted rather more to Tennessee, although the interpretations are of much wider application.

A real virtue of this book is the constant interpretation, in cultural terms ranging from the general to the specific, of archeological phenomena by means of information culled from accounts of historic tribes. The descriptions are of prehistoric cultures with some life, not of artifacts and structural remains alone. But—a valuable part of interpretation—there are very well-presented and well-illustrated descriptions of artifacts, techinques, and technological processes.

Professional archeologists will find

much to argue with in details of data and of interpretation and in some more general matters. Certainly not all of us accept as much population replacement with the advent of each new cultural entity as is implied, and many of us do not accept all of the ethnic identifications which are made. Yet this is a top-notch job by writers thoroughly familiar with the historic and prehistoric material. As such, it may be strongly recommended to the audience for which it was written.

WILLIAM H. SEARS
Florida State Museum, Gainesville

Soils for the Archaeologist. I. W. Cornwall. Macmillan, New York, 1958. 230 pp. Illus. $7.50.

This book is a pioneer undertaking. It fills a need long felt in archeology. One supposes that the archeologist, whose principal concern is the extraction of information from the soil, would have a thorough grounding in the subject of soils. This is apparently not the case. Many reports refer to soils only in vague terms or omit discussions of soils altogether.

The author of this book, I. W. Cornwall of the department of environmental archaeology, Institute of Archaeology, London University, brings to us the benefit of nearly ten years of field and laboratory experience in "learning how to extract relevant information from soils and archaeological deposits."

The chapters include: (part I) "Archaeological deposits"; (part II) "Weathering and soils"; (part III) "Techniques of soil-investigation"; and (part IV) "Interpretation and examples." There is an appendix.

Two approaches are inherent in soil studies for the archeologist. One is the identification of artificial or man-disturbed soils. The other is the identification and study of ancient natural soils (paleopedology). Of intrinsically greater importance, the latter approach may give clues to the environments of ancient cultures.

The book is intended "to take the 'magic' out of soil investigations." Its purpose is also to show what sedimentary petrology and soil science can do towards explaining the phenomena which many archeologists meet daily in their excavations. Certainly, if archeology is to progress, the material surrounding the artifact and represented by various symbols in profile drawings must be handled as carefully and analyzed as well as the artifacts themselves. It has been customary to call in the soil specialist for an analysis if the means are available. Cornwall describes how one can find the answers to some questions with the aid of rudimentary equipment and basic knowledge. It may be argued that the demands made upon the field archeologist in his study of the cultural remains are quite enough to keep him busy. Still he should have some background information concerning what lies behind soil studies and some knowledge of how such studies may help him in the broader analysis of man's past. Moreover, in this regard, he should at least know how to collect soil samples so that they may be studied. He should be in a position to discuss his problems intelligently with the soil scientist. Cooperation may be of little help unless direction to the problem is given.

Cornwall's earlier book, *Bones for the Archaeologist,* has been mildly criticized for its emphasis upon the Old World and its limited applicability to the problems of the New World. His present work deals with a more universal subject, although it, too, is understandably directed to Old World readers (there is only one reference to the work of an American in soil studies). It may be said that in concerning himself with a shorter time span of prehistory than some of his European colleagues, the American archeologist at home may find some of the soil studies inapplicable. However, as is implied, not all Old World archeologists deal with ancient time periods either.

In all, this is a very stimulating book and deserves to be looked into by the field archeologist, whatever his problem in soils.

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Social Mechanisms. Studies in sociological theory. Georg Karlsson. Free Press, Glencoe, Ill., 1958. 156 pp. $5.

The author is concerned with social mechanisms—models which cover only a part of a total social process. He differs from Herbert Simon, who builds models for either rational or socially influenced behavior, by insisting that the model builder simultaneously provide for both rational and irrational determinants. Under three headings—social diffusion, group choice, and interaction—he presents existent theoretical models and selected empirical findings. His criticism of earlier work is blunt and direct when a better model is known to him (see his comment on Stouffer on migration, page 64). But in the suggestions for the improvement of models given at the end of the three main sections of the book the speculations appear *ad hoc* and disjointed, and one wishes that either greater use of nonquantitative social theory or more explicitly stated mathematical criteria had guided the criticism.

The author's contribution, in addition to his function as a reviewer, is a system of accounting equations (page 134). These equations assume the availability in matrix form of probabilities assigned to matters like the future acts of other individuals. As we have come to know from the analysis of chess moves, the speed of growth of alternative sequences of action is very great. It therefore stretches our optimism to believe that the many-faceted social process will be easily tamed by probabilistic approaches. It would properly be difficult to convince behavioral scientists that Karlsson's approach is the most direct route to deeper understanding of the regularities of social behavior, but whoever among them chooses to teach or write on social applications of mathematical models will wish to study and refer to this handsomely printed volume, both for its pioneering classification of earlier studies and for the reports of recent European work.

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Insect Migration. C. B. Williams. Macmillan, New York, 1958. xiii + 235 pp. Illus. + plates. $6.

This handsomely illustrated volume, the latest of the "New Naturalist" series, deals largely with the migration of butterflies and moths. The migration of locusts, dragonflies, ladybird beetles, hover flies and other insects is discussed in varying detail, but the lifelong interest of the author in the Lepidoptera is reflected through the entire book.

Williams defines migration as "continued movement in a more or less definite direction, in which both movement and direction are under the control of the animal concerned." Some other authors restrict the term *migration* to two-way movements.

The book is divided into four parts: introduction, evidence, problems, and methods. The first section gives a general introduction to insect migration and a brief history of the phenomenon. The second is devoted to anecdotal reporting of migrations. The third section—the largest—discusses the origin of migration, possible mechanisms of migrant orientation, the return flight, the relation of population density to migration, and similar problems.

Although it is not at present possible to offer solutions to most of the mysteries of insect migration, Williams presents much thought-provoking data. However, the discussion of the evolution of the migratory habit is unfortunately brief. For instance, the book contains little mention of the regular daily movements of certain butterflies, which might well illustrate "primitive" migratory behavior.

The final section deals with methods of studying migration. The major emphasis is on observation, and the view of the possible fruits of experimental studies is, perhaps, overly pessimistic.

There are an annoying number of typographical errors, misspelling of generic names, incorrect plate references, and so forth. In some cases the choice of generic names is doubtful, and in several instances a species is placed in two different genera on different pages. An appendix giving "the numbers of individuals of twenty-nine species of immigrant butterflies and moths in Britain each year from 1850 to 1955" might well have been omitted in favor of a more comprehensive bibliography (some works mentioned in the text are not cited in the bibliography) or more discussion of movements of insects other than Lepidoptera (such as mosquitoes).

Because the enthusiasm of the author for his subject is contagious, this interesting and well-written book will doubtless do much to stimulate interest in the phenomenon of insect migration.

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Georgia Birds. Thomas D. Burleigh. University of Oklahoma Press, Norman, Okla., 1958. xxix + 746 pp. Illus. $12.50.

Bird Hybrids. A check-list with bibliography. Technical Communication No. 13, Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh. Annie P. Gray. Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England, 1958. x + 390 pp. 50s.

Extinct and Vanishing Birds of the World. Special Publication No. 13. James C. Greenway, Jr. American Committee for International Wild Life Protection, New York, 1958. x + 518 pp. Illus.

The three books reviewed here have little in common besides the mere recording and arranging of information about birds with little or no intention of analyzing or explaining the data they present. Within their scope they represent three quite diverse aspects of bird study: a regional or faunal work, a compilation of hybridization in wild and captive birds, and a record of the passing from the scene of those species which have been the casualties of man's advance over the face of the globe.

The first of these, dealing with the bird life of the state of Georgia, presents an up-to-date account of all the kinds of birds authentically recorded in that state. The individual accounts of each species are written to accord with its actual status in the area and, except for brief statements, no attempt is made to discuss its activities or occurrence elsewhere. In this it succeeds very well and gives every indication of taking its place with other well-known state bird books. The geographic location of the area it covers makes it a particularly welcome addition to regional American works. The account of each species gives a statement of its general distribution, its status in Georgia (given in necessary detail), and one or more paragraphs about its habits and recognition marks. The 35 colored plates from paintings by George M. Sutton are well done, but in the review copy they were, in some cases, too pale. This may be the fault of the printing rather than the painting. The book has an adequate index.

The second book is a straightforward check list, with bibliography, of known avian hybrids. While no great critical appraisal has been made of the surprisingly great number of such occurrences, the individual accounts do cite references that substantiate or cast doubt on the record in question. In other words, it is left to the user of the book to accept or reject a given record. It is too bad that no attempt was made to distinguish between hybrids in the wild state and those in captivity. In the latter category we find many instances of crosses between cage mates that in nature do not occur within thousands of miles of each other. The ducks seem to be the most prone to hybridizing—the mallard has no less than 50 crossings with other species listed; the wood duck, 26; the pintail, 27; and so forth. The literature and other sources appear to have been thoroughly covered, and the result is a useful source of information on bird hybrids.

Greenway's record of extinct and vanishing bird species is, even as a bald record, not as good as either of the above books. One of the things the reader wants to look up is where (in what museums) specimens may be seen of each of these departed species, and here the coverage is very incomplete. The author seems to have been aware of this as he dodges the issue by listing only the specimens known to him, without attempting to make his knowledge more complete. In checking this feature of the book against the collections in the U.S. National Museum, I found that specimens —sometimes in considerable numbers— of nearly three-quarters of the species discussed were not mentioned in the book. What is true of the collections in the National Museum is true of those in other museums as well. The historical data on the various species are similarly incomplete or, in some cases, inaccurate. Thus, the story of the demise of the last passenger pigeon in the zoo at Cincinnati is given correctly for that species, but is repeated, incorrectly, for the Carolina parakeet. The book will undoubtedly be consulted as a source reference for years to come, and it is all the more unfortunate that it is not consistently as good throughout as it is in many places.

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New Books

Morphologie structurale. vol. 1, *Structure statique, formes structurales élémentaires.* vol. 2, *Types d'évolution du relief, théories orgéniques.* Pierre Birot. Presses Universitaires de France, Paris, 1958. 464 pp. vol. 1, F. 1000; vol. 2, F. 1800.

Philosophy of Atomic Physics. Joseph Murdy. Philosophical Library, New York, 1958. 136 pp. $3.75.

The Physics of Elementary Particles. J. D. Jackson. Princeton Univ. Press, Princeton, N.J., 1958. 144 pp. $4.50.

Physiology of Fungi. Vincent W. Cochrane. Wiley, New York; Chapman & Hall, London, 1958. 537 pp. $9.75.

The Practice of Sanitation. Edward S. Hopkins and Wilmer H. Schulze. Williams & Wilkins, Baltimore, Md., ed. 3, 1958. 496 pp. $8.

Problems in Wood Chemistry. Weizmann Science Press of Israel, Jerusalem, 1957 (order from Interscience, New York). 136 pp. $6.75. The lectures and discussions which took place during the meeting of the FAO panel of experts on wood chemistry in Israel in April 1956 are published in this volume.

Process Dynamics. Dynamic behavior of the production process. Donald P. Campbell. Wiley, New York; Chapman & Hall, London, 1958. $10.50.

Quantum Electrodynamics, Selected Papers. Julian Schwinger, Ed. Dover, New York, 1958. 441 pp. $2.45.

Readings in Linear Programming. S. Vajda. Wiley, New York, 1958. 106 pp.

Roads. Fon W. Boardman, Jr. Henry Z. Walck, New York, 1958. 143 pp. *Roads* is a juvenile book that tells the story of road building from the days of the Romans to the modern roads of today. Descriptions of the materials used and the modern road-building machinery are included.

Sampled-Data Control Systems. Eliahu I. Jury. Wiley, New York; Chapman & Hall, London, 1958. 468 pp. $16.

Science. A course of selected reading by authorities. International Univ. Soc., London, ed. 2, 1958 (order from Collings, Inc., New York 17). 345 pp. $4.50. The contents are divided as follows: "The origin and meaning of science"; "The universe"; "Matter and energy"; "Science and everyday life." There is an introductory reading guide by E. N. Da. C. Andrade.

Solid State Physics. Advances in research and applications. vol. 7, Frederick Seitz and David Turnbull, Eds. Academic Press, New York, 1958. 539 pp. $12.

Trends in Genetic Analysis. G. Pontecorvo. Columbia Univ. Press, New York, 1958. 145 pp. $4.

Reports

Mutation in the Protozoan Paramecium multimicronucleatum as a Result of X-irradiation

Abstract. Mutations have been produced in the protozoan *Paramecium multimicronucleatum* by repeatedly exposing clonal cultures of the animals to large dosages of x-irradiation. The descendants of x-rayed survivors showed the following changes, which persisted in culture: destruction and loss of all micronuclei, decrease in vitality and reproductive rate, increase in x-radiation sensitivity, monstrosity, and reduced body size.

Mutations of diverse kinds have been reported as a result of x-irradiation in a number of representative free-living flagellate, ciliate, and ameboid *Protozoa*. Striking changes in size of the giant multinucleate ameba, *Chaos chaos*, were produced by x-radiation of selected dividing animals during the latter part of the mitotic process (*1*). Clones were created which yielded amebas of a size (volume) that averaged about 60 percent that of the parent clone. These changes persisted for 4 years, the duration of the experiment. In similar manner, another size change was produced from this second clone which resulted in another 60 percent reduction.

Experiments were initiated in 1954 in an attempt to breed x-ray–resistant clones of *Paramecium multimicronucleatum* (*2*). As a result, it was discovered that the radiations increased sensitivity rather than resistance. Furthermore, amicronucleate progeny were produced, as well as other persisting changes.

The x-ray generator used operated simultaneously two water-cooled Coolidge tubes in alternate parallel. One tube was mounted permanently on a platform, and the other tube was supported on a counterbalanced arm which allowed it to be moved vertically and in line directly over the fixed tube. The animals were thus irradiated by a cross fire of x-rays from above and below. The x-ray tubes operated at 182 kv peak and at 25 ma, with an equivalent filtration of 0.2 mm of copper. When the tubes were brought as close together as possible, maximal intensity was 5500 r per minute.

For each irradiation experiment, 200 paramecia were selected from rich clonal cultures in desiccated lettuce medium and placed in each of four nylon syringes of 2-ml capacity and free of air spaces, then x-rayed simultaneously. Details of the method and its advantages have been described previously (*3*). Immediately after all irradiation exposures, survivors of the different doses were expressed from the syringes into test tubes filled with buffered lettuce medium containing the bacterium *Aerobacter aerogenes*, which served as the food source. Upon regaining reproductive ability, progeny of the survivors were harvested, placed in the syringes, and irradiated as before. In this manner, six approximately evenly spaced irradiation exposures were given within a 33-day period at varied dosages which resulted in bringing the cumulative clonal dosage to 1000 kr.

Survivors and their progeny were cultivated in lettuce medium and, after a lapse of 10 months from the last exposure to x-rays, were similarly irradiated seven times within another 33-day period to bring the total clonal exposure for both periods to 1800 kr. The use of the four syringes at one time provided a convenient means of varying the exposure dosage. For example, paramecia in the first, second, third, and fourth syringes were exposed to dosages of 50, 100, 150, and 200 kr, respectively. For the second exposure, given later to progeny of the survivors of the preceding irradiation, the dosage was increased. Thus, specimens in the first syringe next received 100 instead of 50 kr; those in the second, 150 instead of 100 kr; and so on. In later irradiation periods, progeny of irradiated survivors were generally exposed to 100 to 250 kr, although occasionally doses up to 400 kr were employed.

Control and irradiated animals were stained by means of the Feulgen reaction, after fixation in Schaudinn's fluid.

One conspicuous result of this type of irradiation is the complete destruction of all micronuclei yielding entirely amicronucleate clones of animals. Unirradiated control specimens possessed three (rarely four) vesicular micronuclei, each measuring 2.5 μ. The disappearance of the micronuclei was gradual. Clones investigated cytologically after having received 1000 kr revealed 8 percent with two micronuclei, 32 percent with one micronucleus, and 60 percent amicronucleate. After clonal exposure to a total of 1800 kr, all micronuclei were destroyed (Fig. 1).

The size and shape of the organisms were altered as a result of the irradiation—characteristics which persisted even more than 1 year after the final exposure to x-radiation. Measurements of 50 living control specimens averaged 206 μ (range, 190 to 228 μ), while a like number of the heavily irradiated clonal specimens averaged 144 μ (range, 122 to 175 μ). Instead of being "cigar-shaped" and streamlined, like the controls, specimens from the heavily irradiated clones were broader and ellipsoidal.

Additional persisting characteristics of specimens from clones irradiated in this manner even 1 year after the last x-ray exposure are the following: decreased reproductive rate, greater x-radiation sensitivity, reduced swimming vigor, and occasional occurrence of monstrosity. Data based upon daily isolation of specimens in spot plates showed that the reproductive rate of well-fed control animals occasionally reached three divisions per day, and generally not less than two, while clonally irradiated specimens possessed a fission rate that rarely reached two divisions per day (24° ± 1.5°C).

Animals from clonal cultures previously irradiated with the cumulative dose of 1800 kr were more radiosensitive than those irradiated for the first time.

Fig. 1. (Left) Three small vesicular micronuclei to the left of the large, compact macronucleus of a normal unirradiated animal. (Right) Amicronucleate condition showing only macronucleus, since micronuclei have been destroyed as a result of the x-irradiation. (× 600)

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

For example, in one experiment specimens which had been treated in identical manner by irradiation and isolation were then observed at least five times throughout a 48-hour period after exposure to four different doses, ranging from 85 to 343 kr. The 50 control specimens irradiated for the first time with 343 kr showed a survival rate of 58 percent. In contrast, the 31 specimens from the cumulatively irradiated (1800 kr) clone, after exposure to 343 kr, showed a survival rate of 45 percent 48 hours after irradiation.

X-irradiation has been shown to effect micronuclear number in certain other ciliate *Protozoa*. When specimens of *Paramecium aurelia*, which possess two vesicular micronuclei, were irradiated with single doses of from 200 to 537.4 kr, allowed to multiply for 24 hours, and then killed and stained for micronuclear examination, it was reported that the fraction of specimens with less than two micronuclei increased with increase in dosage while the fraction with two—the normal number—decreased (*4*). In the ciliate *Tetrahymena pyriformis*, which has one micronucleus, haploid exconjugants were produced as a result of crossing one clone that was exposed to 400,000 r with nonirradiated cells of opposite mating type. After two haploids were crossed, a clone resulted which showed 80 to 90 percent amicronucleate animals (*5*). When cultures of two different strains of *T. corlissi* were successively and heavily x-irradiated in a manner somewhat similar to that which I first used in 1954 (*2*), amicronucleate races were also produced (*6*).

During the past 30 years, some paramecia collected in nature revealed the amicronucleate condition (*7*). These naturally occurring amicronucleate forms yielded races which have proved to be as vigorous as their micronucleate sisters. It would appear, at least in these instances, that the micronucleus is unnecessary to the life of ciliates which depend upon asexual reproduction alone. Indeed, amicronucleate races can mate and conjugate with micronucleate ones of opposite mating type.

On the other hand, Miyake (*8*) treated dividing specimens of *Paramecium caudatum*—which has but one micronucleus—with urea and created amicronucleate and bimicronucleate races. He reported that loss of all micronuclei was usually followed by considerable decrease in vitality, fission rate, and body size—all characteristics which I found in the irradiated, amicronucleate animals. Miyake concluded that the micronucleus of *P. caudatum* is a fundamental part of the cell and that the increase or decrease of the number of micronuclei causes a physiological imbalance resulting in the accompanying deleterious effects.

In the heavily irradiated clones of *Paramecium multimicronucleatum* discussed here, the attribution of decrease in vigor, size, reproductive rate, and radioresistance to the loss of micronuclei is untenable, since amicronucleate races of ciliate *Protozoa* which have all the normal and vigorous characteristics of micronucleate races occur in nature. The effects induced by x-irradiation in *P. multimicronucleatum* are more probably caused by the alteration of the sets of genes which are located in the macronucleus (*9*). The experiments suggest that subjecting these organisms and their progeny to repeated exposure of x-irradiation yields mutations which are deleterious to the race (*10*).

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8 September 1958

Ozone in High Concentrations as Cause of Tobacco Leaf Injury

Abstract. Evidence obtained by means of rubber strip tests and an ozone recorder indicates the presence of abnormal concentrations of ozone in the atmosphere at times. Excellent correlation was obtained between appearance of "weather fleck" in tobacco and high values for ozone. The great similarity between lesions occurring naturally and those produced by ozone in chambers also indicates that ozone is the probable inciting agent of weather fleck. Varietal differences exist. Study of stomatal action helped to explain variation in leaf injury.

Tobacco leaf injury known as "weather fleck" or "fleck" has become a serious problem in the production of cigar-wrapper tobacco in the Connecticut Valley (*1*). Fleck has been observed on flue-cured tobacco in North Carolina and in Ontario, Canada, and on other tobacco types in some areas. Since 1954, and perhaps earlier, fleck of varying degrees of severity has developed on tobacco in plots at Beltsville, Md., about 6 miles northeast of the District of Columbia.

Research in 1958 at Beltsville and at Riverside, Calif., provides evidence that the inciting agent of tobacco weather fleck is high concentrations of ozone. Formation of ozone by photochemical reactions involving nitrogen dioxide, certain hydrocarbons, or other air-borne chemicals identified in the Los Angeles area is known to occur (*2*). On tobacco, as on bean (*3*) and grape (*4*), the small lesions occur on the upper leaf surface. Primary lesions are restricted to the palisade layer (*1, 4*). After a day the larger lesions, which usually do not exceed 3 mm in diameter, may appear also on the lower leaf surface. Leaf injury progresses from the bottom to the top of the plant. Normally, leaves are not susceptible until they are fully expanded.

Stretched rubber is used as a specific test for ozone (*5*). To provide tension, the strips of rubber are tied in loop form (*2*). During September, daily exposures of rubber strips were made in the tobacco plots in the hope of correlating fleck appearance with days of high ozone concentration. Ozone concentration based on cracking of rubber strips for each exposure date was evaluated by C. E. Bradley and A. J. Haagen-Smit of California Institute of Technology. From 16 September to 22 October a continuous recorder of atmospheric ozone was operated in the field. This recorder was a prototype of model 725-2 ozone recorder made by Mast Development Corporation (Davenport, Iowa), which was on loan for test purposes to the U.S. Public Health Service (*6*). Although the measurements, based upon the oxidation of potassium iodide solution, are believed to be reliable, further tests are planned to determine the specificity of the instrument for ozone.

Important to these studies were cigar-wrapper varieties of tobacco from the Connecticut Valley. One variety, designated "C" (*7*), is so susceptible to fleck that it cannot be grown for commercial tobacco production. A resistant variety is designated "B" (*8*). Early, medium, and late plantings of the cigar-wrapper varieties were made at Beltsville, both under a cloth shade tent and without a shade tent. During September and October observations were made each day for the appearance of new fleck symptoms, especially in the medium and late plantings. In the early planting, the fleck outbreaks in July and August resulted in lesions on 92 and 64 percent of leaves of varieties C and B, respectively.

Studies conducted in California showed that tobacco was very sensitive to ozone, and the flecks produced by ozone were similar to naturally occurring fleck. The varieties susceptible and resistant to naturally occurring fleck showed 72.0 and 17.5 percent, respectively, of leaves in-

Table 1. Accumulative injury from ozone fumigation on fleck-resistant and fleck-susceptible tobacco varieties, Riverside, California, 1958.

Treatment			Damage	
Date	Hours	Ozone (pphm)	Total leaves flecked (%)	Index of average leaf injury per plant*
		B (fleck-resistant)		
19 Aug.	6.5	21	2.5	0.0
20 Aug.	6.5	26	3.0	0.0
21 Aug.	6.0	29	17.5	0.3
		C (fleck-susceptible)		
19 Aug.	6.5	21	46.0	0.8
20 Aug.	6.5	26	62.5	1.3
21 Aug.	6.0	29	72.0	3.5

* The injury to each leaf was rated from 1 to 10 (mild to severe); the index was obtained by dividing the total of the injury values by the number of leaves per plant. Data were taken 1 day after each fumigation date shown.

Table 2. Ozone concentration for different dates in 1958 in tobacco-breeding plots, Beltsville, Maryland.

Date	Total time above 20 pphm (hr)	Time maximum value was reached	Ozone concentration (pphm by volume)			
			Av. 24-hr period	Av. 8-hr period (9 A.M. to 5 P.M.)	Range in 24-hr period	
					Min.	Max.
23 Sept.	0.8	3:02 P.M.	4.5	12.4	0	31
26 Sept.	1.6*	9:55 A.M.	5.4	14.3	0.5	37
8 Oct.	0.0	3:05 P.M.	1.5	4.4	0	9
9 Oct.	3.3	2:15 P.M.	6.0	16.9	0	38
10 Oct.	1.4*	10:23 A.M.	5.9	12.1	0	50
16 Oct.	1.8*	11:08 A.M.	6.0	15.7	0	43

* Total for two peak periods with values above 20 pphm; on 9 Oct. and 23 Sept. there was only one peak period on each date.

jured after exposure to ozone concentrations of about 25 parts per 100 million (pphm) for about 6 hours on three consecutive dates (Table 1). Results of fumigation experiments indicate that the tobacco is relatively resistant to the reaction products of ozone and hydrocarbons, the toxicants responsible for "smog damage." Smog injury appears primarily on the lower leaf surface and can be distinguished from injury caused by ozone, which appears on the upper leaf surface (*3*).

At Beltsville on 15 September in the medium planting and on 10 October in the late planting there were outbreaks of fleck. The new lesions were confined to the upper leaf surface and had a water-soaked appearance at first. In about 48 hours lesions changed from brown to white or gray, especially on the most vigorous plants. Peak levels of ozone occurred on the day before each outbreak. The concentration of ozone on 14 September, determined from the cracking of rubber strips, was 2.2 times as high as the average for the 16-day period prior to that date.

With the ozone recorder, highest values were obtained in the middle of the day, and values were zero or very low during the night and early morning hours (Table 2). On 8 October the daytime values also were relatively low and may be considered fairly typical of ozone concentration for most days for which data are available. Data on ozone concentration are also presented, in Table 2, for the five highest-value days. These were sunny, warm days with light winds. The highest average ozone value for the 8-hour period 9 A.M. to 5 P.M. was recorded on 9 October. On this date a maximum of 38 pphm was reached at 2:15 P.M., and concentrations ranged above 20 pphm continuously for 3.3 hours. New fleck symptoms appeared on the morning of 10 October on about half of the leaves in a late planting of the susceptible variety C, both on those grown under the shade tent and on those grown without shade, but none were observed in a comparable planting of the variety B. A small increase in fleck was detected also on 24 September and on 17 October but not on other dates. No new fleck symptoms appeared over a 7-week period except after days with high ozone concentration, but some high-value days were not followed by the appearance of new fleck symptoms.

Examination of ozone values and correlation of these with the appearance of symptoms suggest that a threshold value of approximately 20 pphm may be critical for the development of fleck on variety C. Such values, perhaps, would need to be maintained for about 3 hours to produce easily recognizable new injury on this susceptible tobacco variety grown under conditions of culture such as those found at Beltsville in September and October 1958—months with relatively low rainfall. Higher maximum concentrations than those on 9 October were recorded on 10 October (50 pphm) and 16 October (43 pphm). On these days values above 20 pphm were observed for only 1.4 and 1.8 hours, respectively; these times represent a combination of two peak periods of relatively short duration which occurred on each of these days (Table 2).

The extent of increase in fleck injury following a day of high ozone concentration is determined in part by amounts of susceptible leaf tissue exposed—that is, there would be less damage after the second consecutive day with high values than if 2 high-value days were separated by a period of 2 weeks or more. This phenomenon would account for the relatively large increase in fleck symptoms on 15 September, as new fleck lesions did not appear during September prior to that date.

Most folded leaves had very little or no fleck injury beneath the folds. Tests of stomatal behavior based upon penetration of 100-percent alcohol or benzene (*9*) gave evidence that stomata in the shaded portion of the leaf were closed during bright days. The difference in stomatal behavior during the day, when ozone was high, was sufficiently marked to suggest exclusion of air containing the toxicant, and prevention of injury thereby. Similarly, fleck did not develop after shading with strips of black paper in contact with the upper leaf surface. Fleck development was prevented also by application of lanolin to the lower leaf surface, where stomata are most numerous and active, or by the enclosure of leaves in polyethylene bags to exclude air with high concentrations of the toxicant. More extensive research on the relation of ozone to the tobacco leaf injury is anticipated next season.

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Possible Biochemical Implications of the Crystal Structure of Biotin

Abstract. An examination of the molecular architecture of biotin, as determined by x-ray crystallographic analysis, has indicated that biotin may be capable of forming an intramolecular hydrogen bond in solution. A review of various chemical analogs of the vitamin has shown a close correlation between the possibility of forming such a hydrogen bond and biotin-like activity.

A recent x-ray analysis of the crystal structure of biotin (*1*) has established the stereochemistry of the molecule and, in particular, shown it to have the *cis-cis* configuration at the three asymmetric carbon atoms (Fig. 1). Indications that both the stereoisomerism (*2*) and the length of the aliphatic chain (*3, 4*) are specific for biological activity prompted a detailed examination of the molecular structure, in the hope that this might throw some light on the mode of action of the vitamin.

An accurate scale model of the biotin structure and—for comparison—analogous models incorporating the alternative configurations at the asymmetric centers and aliphatic chains of several different lengths were constructed. Though the ring portions of the models were rigid, flexibility was allowed in the construction of the side chains so that the effects of rotation about carbon-carbon single bonds might be examined.

While in general the various interatomic distances and angles of the biotin molecule conform with those found in similar structures, there are some unusual features near the junction of the ring and chain portions of the molecule. There is a particularly short separation (2.8 A) between atoms C_{10} and N_7, and a C_8–C_9–C_{10} angle of 119°. This unusually large angle, which is presumably the result of repulsion between C_{10} and N_7, would appear to facilitate rotation in solution about the C_9–C_{10} single bond, which would otherwise be restricted by steric hindrance. When the ring and chain portions of the biotin model were folded together, by a rotation about the C_9–C_{10} bond, it was found that the chemically reactive centers in the ureido ring system and the carboxyl group could approach each other closely, while Van der Waal's distances of separation were maintained between the other atoms of the chain and the ring system. In particular it was found that such a folding, together with only small rotations about other single bonds in the chain, would enable the structure to meet the rather stringent physical requirements for hydrogen bonding between O_6 and one of the carboxyl oxygen atoms (Fig. 2) (*5*).

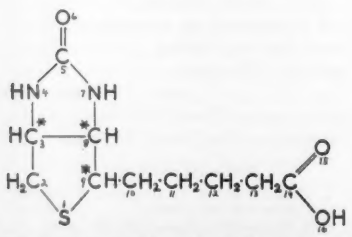

Fig. 1. Structural formula of biotin (atoms numbered arbitrarily).

A study of the various other models indicated that the short C_{10}–N_7 separation in biotin (and presumably the large C_8–C_9–C_{10} angle) is a direct consequence of the *cis-cis* configuration. Furthermore, none of the three stereoisomers of biotin, or molecules with different chain lengths, appear to be capable of forming an intramolecular hydrogen bond, the possibility of which depends critically on both the steric configuration and the chain length.

Supporting evidence for the implication of this type of hydrogen bonding in the biological function of the vitamin appears to be provided by studies of the biotin-like properties of several dozen chemical analogs of the vitamin. These studies have indicated a high degree of biological specificity for the structure of biotin, not only with regard to the steric configuration (*2*) and the length of the aliphatic chain (*3, 4*), but also with regard to the ureido ring system (*6*) and the presence of an oxygen atom at the position of the carboxyl group (*4*). However, it is possible to modify the ring containing the sulfur atom (*7*) and to prepare amides and amino acid derivatives of biotin (*8*)—neither of which need necessarily prevent intramolecular hydrogen bonding—without destroying the biological activity.

It is not quite clear how the formation of an intramolecular hydrogen bond would affect the chemical reactivity of the molecule. In aqueous solution such a hydrogen bond would presumably be unstable, allowing the biotin molecule to alternate between two different states. The formation of the hydrogen bond might be expected to alter the charge

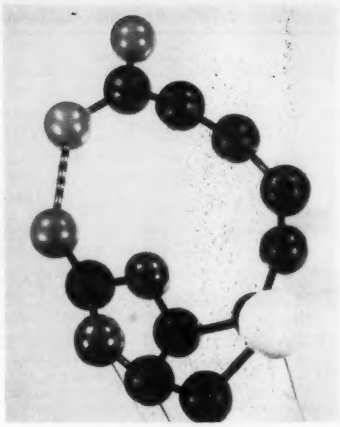

Fig. 2. Possible mode of intramolecular hydrogen bonding in biotin: O_{16} lies in the plane of the ureido ring system; O_6 lies in the plane of the carboxyl group; the distance O_{16}–O_6 is about 2.6 A, and all the other distances between atoms of the chain and those of the ring system (except N_7–C_{10}) are greater than 3.4 A. Angles C_{14}–O_{16}–O_6 and C_5–O_6–O_{16} are both about 120°.

distribution in the ureido ring system and to displace the keto-enol equilibrium to enol, resulting in a change of chemical reactivity at the nitrogen atoms, or a system of hydrogen transport along the lines suggested by Lichstein (*9*), whereby the substrate may donate a proton at one point and accept one at another during a keto-enol transition (*10*).

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27 August 1958

Enhancement by Inositol of the Nodulation of Isolated Bean Roots

Abstract. The percentage of isolated bean roots nodulated and the number of nodules per root were increased by the addition of mesoinositol to the agar medium into which the bases of bean roots were inserted. The following were without marked effect: glycine, thiamine, pyrodoxine, niacin, indoleacetic acid, gibberellic acid, kinetin, adenine, adenosinetriphosphate, biotin, riboflavin, calcium pantothenate, and folic acid.

With a modified method of aseptic isolated root culture (*1*) it has been possible to obtain rather widely fluctuating percentages of nodulated roots (averaging 50 percent) with 1.9 to 3.3 nodules per nodulated root (*2*). The object of the experiments reported here was to increase nodulation and to improve the consistency of the results, with the final aim of gaining a better understanding of the factors involved in nodule formation.

Isolated roots of *Phaseolus vulgaris* L., var. Pencil Pod, black wax bean were grown and inoculated as described earlier (*2*), except that three roots instead of one were grown per Petri dish. Each dish carried three agar-containing vials and 50 g of washed silica sand moistened with 10 ml of the inorganic salts of medium "0" (*2*). The cut end of each root was inserted into the agar medium in a 12 by 35-mm shell vial, and the vial was laid on its side in the Petri dish. The vials contained a basal medium consisting of 10 percent sucrose and glycine, thiamine, pyridoxine, and niacin at the levels indicated for the organic constituents of medium "0," or 20 times higher. Thus, the roots were nourished by the inorganic salts medium in the sand and by other materials furnished from the base of the root in contact with the agar. The roots were maintained in the dark at 26°C. Fifteen to 20 days after inoculation with a mixture of the Nitragin Company's strains 3I6C11, 3I6C13, and 3I6C17 of *Rhizobium phaseoli* Dangeard, the roots were examined for nodules.

Experiments were run in which the medium in the vials was altered to determine the inference on nodulation. When glycine, thiamine, pyridoxine, and niacin were increased to a level 20 times higher than that in medium "0," no significant increase in nodulation occurred. Similar negative results were obtained with indoleacetic acid ($10^{-10}M$) and gibberellic acid (50 and 250 mg/lit.).

Since nodulation was enhanced by the addition of a mixture of $Ca(NO_3)_2 \cdot 4H_2O$ (300 mg/lit.), KNO_3 (80 mg/lit.), kinetin (0.05 mg/lit.), *d*-biotin (0.05 mg/lit.), riboflavin (0.05 mg/lit.), folic acid (0.5 mg/lit.), calcium pantothenate (5 mg/lit.), and mesoinositol (100 mg/lit.), the effects of the nitrates of kinetin, and of the five vitamins were tested separately. The results presented in Tables 1 and 2 indicate that kinetin did not enhance nodulation—a result confirmed by other experiments (not shown in the tables) in which this substance was inactive at concentrations of 0.025, 0.05, 0.1, and 0.5 mg/lit., either by itself or in combination with adenine (10 mg/lit.), or sodium adenosinetriphosphate (100 mg/lit.). On the other hand, the results shown in Tables 1 and 2 indicate enhancement by nitrate and by the vitamin mixture; Tables 2 and 3 show that the effect of the vitamin mixture can be attributed to mesoinositol.

The results obtained with nitrate confirm and extend previous work (*2*) which showed that nitrate, while inhibitory when added to the medium in the dish, did not inhibit nodulation if it was included with the nutrients supplied in the vial. It is interesting to note that the beneficial effect of nitrate apparently does not depend merely on the amount of nitrogen added (43 mg/lit.), for no effect was obtained by increasing glycine 20 times (an increase of 56 mg of N per liter). On the other hand, it seems improbable that the effect can be attributed to the cations Ca and K, for both are abundant in the inorganic medium. Although this point needs further clarification, it seems that the stimulation noted results from better utilization of nitrate than of glycine.

The striking promotion of nodulation by mesoinositol was unexpected, for mesoinositol has never been associated with nodule formation or function. Furthermore, it apparently is not required by the rhizobia. It is included in several vitamin mixtures used in plant tissue cultures (*3*), but its specific role in such mixtures has received little study. Jacquiot (*4*) found that it favors bud formation by elm cambial tissue, and there are several reports of its effect on cell division [see, for example (*5*)]. While the present experiments were in progress, Braun (*6*) reported that fully altered plant tumor tissue will grow in White's basal culture medium but that

Table 1. Effect of omitting one component at a time from the basal medium supplemented with nitrate, kinetin, and the mixture of five vitamins. Columns A, percentage of roots nodulated; columns B, mean number of nodules per nodulated root.

Expt.	Complete mixture		Complete mixture					
			Minus nitrate		Minus kinetin		Minus vitamins	
	A	B	A	B	A	B	A	B
1	71	5.5	53	5.1	69	6.6	43	3.9
2	65	8.8	65	7.9	65	8.1	59	3.9
3	77	9.0	64	7.0				
4	88	10.0						

Table 2. Effect of omitting one vitamin at a time from the basal medium supplemented with the other four vitamins and nitrate. Columns A, percentage of roots nodulated; columns B, mean number of nodules per nodulated root.

Expt.	Basal medium		Basal medium + nitrate		Complete mixture: basal medium + nitrate + vitamins		Complete mixture									
							Minus inositol		Minus biotin		Minus riboflavin		Minus Ca pantothenate		Minus folic acid	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
5					88	10.0	77	6.6	92	10.6	87	9.5	94	13.7	88	12.1
6	68	3.6	83	5.4	94	8.6	85	4.9	93	9.0	93	10.0	90	10.1	93	9.1

Table 3. Effect of adding each one of the vitamins to the basal medium supplemented with nitrate. Columns A, percentage of roots nodulated; columns B, mean number of nodules per nodulated root.

Expt.	Basal medium supplemented with nitrate									
	Plus inositol		Plus biotin		Plus riboflavin		Plus Ca pantothenate		Plus folic acid	
	A	B	A	B	A	B	A	B	A	B
7	84	9.5	73	5.8	73	5.2	70	6.6	67	4.5

cells with lesser degrees of neoplastic change have more complex requirements, mesoinositol being prominent among the required components.

An evaluation of the significance of the present findings regarding the promotion of nodulation by mesoinositol must await further experimentation (*7*).

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Fibrillation and Potassium Influx

Abstract. Absolute influx and efflux of potassium-42 have been measured in isolated rabbit atria during acetylcholine-induced fibrillation. The efflux of potassium was increased three to four times; influx was not changed. The data are interpreted as indicating that an inhibition of active K uptake is not involved in the initiation of fibrillation, and that the process results from a marked increase in Na permeability.

Fibrillation has been induced by stimulating, at high frequency, isolated rabbit atria suspended in low potassium (K) media (*1*) in the presence of acetylcholine. Ion-exchange studies revealed that fibrillation began when the rate of net loss of K and gain of sodium (Na) exceeded critical values (*2*). Isotope investigations showed that with the onset of fibrillation the efflux of K reached a rate three to four times that of the spontaneously beating preparation (*3*). Net losses occurring under the conditions of the experiment prevented an accurate determination of influx. Therefore, we were unable to ascertain the nature of the permeability change involved in the process.

Recently a method has been devised (*4*) which permits an estimation of K^{42} influx with the onset of fibrillation. Absolute rates of influx were calculated by methods described by Keynes and Lewis (*5*). Influx is given by the product of the initial rate of entry of K^{42} to the tissue, the sensitivity of the counter, and the volume–to–surface-area ratio of the atrial fibers (*6*). The initial rate of entry can be obtained from the following relation:

$$\left(\frac{dy}{dt}\right)_{t=0} = \frac{Y}{T}\left(\frac{kt}{1-e^{-kt}}\right)$$

where Y is counts in the tissue after time T and k is the specific transfer coefficient obtained from efflux. During fibrillation, k was estimated to be of the order of 7.5 to 8.0×10^{-4} sec^{-1} (*3*).

Table 1 is a summary of our findings. First, it should be noted that acetylcholine increases both efflux and influx of K, whereas during fibrillation only an increase in efflux is obtained. Influx remains essentially unchanged. Thus, the changes induced by acetylcholine result from an increase in membrane permeability to K, while those that occur during fibrillation cannot be so interpreted. Earlier studies on the effects of temperature on efflux during fibrillation and acetylcholine treatment also suggested that different mechanisms were involved (*7*). A marked increase in Na permeability will explain the findings during fibrillation: Potassium leaves the tissue in exchange for sodium. This is in keeping with an earlier finding that the rate of entry of Na^{24} to atria was markedly increased (15 to 20 times) during the arrhythmia (*7*). These data suggested that the quantity of Na entering the tissue exceeded that of K which was lost. This would indicate that there was a sudden release of an anion in the tissue or, more probably, that membrane permeability to chloride is increased.

It should be noted that the mechanism proposed for the permeability change accompanying the onset of fibrillation is similar to that postulated for excitation and conduction in nerve (*8*) but differs in that K permeability is not increased. This is probably one of the factors responsible for the observed differences between the electrical properties of heart muscle and nerve (*9*).

Finally, it should be pointed out that the normal or slightly increased rate of influx during the early phases of fibrillation indicates that a depression of active transport is not a factor in the initiation of the arrhythmia, as was recently suggested by Goodford (*10*).

Table 1. Effects of acetylcholine and fibrillation on the transmembrane flux of potassium. Fibrillation was induced by stimulating at 1200 count/min for 1 min. Atria were suspended in Ringer's solution containing 1.35 mmole of K^+ in the presence of acetylcholine (6.4×10^{-5} mole).

No. of observations	Experiment	Absolute flux (pmole cm^{-2} sec^{-1})	
		Influx	Efflux
8	Control	1.15 ± .08	4.32 ± .14
10	5 min after addition of acetylcholine (6.4×10^{-5} mole)	2.22 ± .13	7.88 ± .62
5	5 min after onset of fibrillation	1.20 ± .11	12.7 ± .48

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17 July 1958

Failure of Nicotine to Affect Development of Offspring When Administered to Pregnant Rats

Abstract. Administration of nicotine to rats at any point in pregnancy has no apparent effect upon completion or duration of pregnancy, or upon body development, litter size, weight, or mortality of offspring. These results differ sharply from the effects in mice reported by others. The possible etiologic significance of anoxia in the malformations reported in mice is discussed.

Nishimura and Nakai recently reported (*1*) the development of a variety of skeletal anomalies, predominantly of the limbs, in the offspring (sacrificed at term, or examined at midpregnancy) of mice injected with a 0.1-percent aqueous solution of nicotine (0.025 mg/g) sometime between the 5th and 15th days of pregnancy. The percentage of congenital malformations, the number of pregnancies undergoing complete resorption, and the lethal effects of the drug upon the embryo were greatest when the drug was administered daily on days 9, 10, and 11 of pregnancy, although any or all of these effects could be produced, though to a considerably lesser

extent, by giving nicotine on any of the other days of pregnancy covered in the study. Litter size of mice whose pregnancies did not end in total resorption was found to be significantly different from that of the normal controls, though the average weight of such survivors, at birth, was relatively normal. Because the results in this laboratory differed markedly from those of Nishimura and Nakai just noted, I thought it appropriate at this time to report our experience with the use of nicotine as a potential teratogenic agent in the pregnant rat (*2*).

Rats from our stock colony (said to originate from Sherman strain and arbitrarily bred as a closed colony for at least 15 generations), raised on a standard Rockland Farms pellet ration, were mated between 4:30 and 5:00 each evening. The presence of sperm in the vagina (which was examined between 9:00 and 10:00 the following morning) was taken as presumptive evidence of pregnancy, and the morning of the positive smear was counted as the first day of pregnancy. Rats were injected subcutaneously, for 4 days, on the 9th, 10th, 11th, and 12th days of pregnancy, or daily for the first 20 days of pregnancy, with either 1.5 mg or 4.5 mg of nicotine per kilogram. A 0.1-percent aqueous solution of the chemically pure liquid alkaloid base (Fisher) was used for all dosages.

Preliminary findings indicated that a dose of 1.5 mg/kg would avoid the possibly complicating factor of convulsion in almost 100 percent of the injections but that this dose was nevertheless sufficiently effective to result in a gradually increasing flaccid paralysis (most apparent in the rear limbs), abolition of the placing reactions, and increase in rate of respiration. A dose of 4.5 mg/kg quickly resulted in loss of locomotor ability and in profoundly altered respiration. Mild clonic activity of the limbs, together with concave arching of the back and total-body spasms, was noted in approximately 30 percent of the injections. No deaths resulted from either dosage.

All animals were observed throughout pregnancy, and daily weights were taken in order to detect possible alterations in the course of pregnancy. Litters were carefully examined and weighed as soon after birth as possible. As controls for the treated animals, a small group of pregnant rats injected with saline (see Table 1) was run, and the offspring were examined similarly. Moreover, colony records of length of pregnancy, number of living and dead offspring in litter at birth, and weight at birth provided an essential background against which to evaluate these factors in the experimental litters.

Table 1 summarizes the effects of nicotine in the experimental and control groups. None of the nicotine treatments, regardless of dosage or of period of pregnancy covered, had an adverse effect upon litter size, weight of young at birth, or number of offspring dead at birth. In all cases the dead offspring appeared to be full-term animals, and their well-preserved condition suggested that death had occurred in the immediate perinatal period. In no instance was there a case of pregnancy undergoing complete resorption or, to judge by litter size at birth, any indication of a lethal effect of nicotine upon embryo or fetus. Duration of pregnancy was normal in every experimental animal.

Table 1. Effects of nicotine, administered subcutaneously to pregnant rats, on outcome of pregnancy and upon offspring examined at birth.

Treatment (dosage and days of pregnancy when injected)	No. of females treated	No. of females delivering*†	Av. length of gestation (day)‡	Total No. of offspring born	Total No. of offspring dead at birth†§	Distribution of dead by litter‖	Av. No. of offspring (live and dead) per litter‡	Av. wt. of living offspring at birth (g)‡§
1.5 mg/kg (9–12 days)	36	34(94.4)	22.8 ± 0.11	338	16(4.7)	3, 3, 4, 3, 2, 1	10.2 ± 0.35	5.3 ± 0.08
1.5 mg/kg (1–20 days)	12	11(91.7)	22.5 ± 0.02	116	1(0.9)	1	10.5 ± 0.56	5.2 ± 0.16
4.5 mg/kg (9–12 days)	7	5(71.4)	22.2 ± 0.20	52	1(1.9)	1	10.4 ± 0.59	5.2 ± 0.28
Saline controls#	7	5(71.4)	22.6 ± 0.25	56	0(0)	0	11.2 ± 0.58	5.3 ± 0.29
Colony record controls		56/68 (82.4)**	22.8 ± 0.18	545	28(5.1)	3, 1, 3, 3, 1, 7, 2, 2, 2, 1, 1, 1, 1	9.8 ± 0.43	5.5 ± 0.14 [††

* Rats which failed to deliver in these groups did not give any indication of pregnancy in terms of daily weight gain. Lack of pregnancy was confirmed by post-mortem examination of ovaries and uterus, 15 to 20 days after insemination.
† Percentage in parentheses.
‡ Standard error of the mean.
§ The term *at birth* refers to a period ranging from direct observation of offspring being delivered to as much as one-half day thereafter. In all cases weights were taken after the babies had an opportunity to suckle. The distribution of periods at which postnatal observations were first made did not differ significantly among the groups.
‖ Each entry represents the number of offspring dead in a single litter.
Volumes injected equivalent to those used in 4.5 mg/kg group.
** The denominator represents the last 68 females mated, of which 56 delivered litters. The failure of approximately one of every five inseminated females to become pregnant represents a reliable estimate of our long-term experience with the colony.
†† Based on 56 offspring from 6 litters.

In further contrast to the report of Nishimura and Nakai, not a single animal (of a total of 506 offspring) in any experimental series was found, on systematic gross examination at birth, to display any type of malformation. Post-mortem examination of animals dead at birth also failed to reveal evidence of congenital defect. It is not impossible that continued observation of the young after birth might reveal deficiencies in growth and development (*3*) or the presence of other defects—for example, decreased fertility (*4*). Detailed study of the offspring during growth, plus systematic post-mortem examination for the presence of malformations, is, however, still lacking.

The sharp difference between total absence of skeletal malformations at birth in our rats, as compared with the findings of Nishimura and Nakai in mice, may represent a striking species difference in response to the teratogenic potency of nicotine. Other than this, a possible basis for our results may be sought in the difference in dosage of drug used. The dose employed by the Japanese workers would amount to 25 mg/kg, or approximately six to 17 times the dose used by us. Doses based on those of Nishimura and Nakai with mice would, in our animals, uniformly produce severe convulsions, which, according to our experience, would be fatal in the majority of cases. In itself this suggests an interesting species difference in the maternal animal's tolerance for nicotine, though it does not clarify the basis for the difference in effects upon the fetus.

Nishimura and Nakai believe the malformations they find can be ascribed to the direct action of nicotine upon embryonic cells. In view of the known cardiovascular responses to nicotine, coupled with its curariform effect upon the muscles of respiration (as well as its depressive action on medullary respiratory centers), the possible role of anoxia in the production of these malformations also must be considered. Ingalls and his coworkers (*5*) have shown that exposure of the pregnant mouse to different degrees of frank anoxia, at various stages of gestation, results in a continuum of damage to the conceptus ranging from total resorption to anomalies present at birth. The latter involve not only striking defects of the nervous system but also clear abnormalities of the skeletal structure, including cleft palate and malformed vertebrae and ribs.

Whatever the intervening mechanism or mechanisms in the production of congenital malformations may be, it appears that large quantities of any of a wide variety of agents (*6*) administered to the maternal animal at particular stages of pregnancy, will frequently result in either the death of the conceptus or in defects present in the offspring at birth. The nature of these de-

fects in many instances does not appear to be specific for the *agent* used but may be more clearly related to the intensity of the treatment and the period of pregnancy at which it is given, as well as to the interplay of these factors with genetic determinants in the developing organism (*7*).

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24 July 1958

Alginase in the Sea Urchin Strongylocentrotus purpuratus

Abstract. Viscosimetric evidence of alginase activity is given for the intestine and the intestinal contents of a sea urchin. The alginase activity of the gut wall and that of the contents of the gut differ in *p*H optima; this suggests that there may be two sources of alginase. The enzyme (or enzymes) depolymerizes algin.

Alginase may be a common digestive enzyme in invertebrates which feed upon brown algae. The presence of the enzyme has been noted in intestinal extracts of an abalone, *Haliotus giganteus,* and a sea urchin, *Sphaerechinus pulcherissima* (*1*), and in a sea hare, *Aplysia punctata* (*2*).

The alginase from Haliotus (*2*), like that of certain bacteria (*3*), appears to hydrolyze algin to free mannuronic acid, after a period of incubation. As with pectic-acid hydrolysis by pectin-polygalacturonase (*4*), the viscosity of the algin solution is much reduced before measurable reducing sugar appears (*2*). By analogy with the nomenclature of pectic enzymes (*4*), this alginase may be termed algin-polymannuronase.

In *Cryptochiton stelleri* (*5*) and in the sea urchin *Strongylocentrotus purpuratus,* alginase activity has not yet been demonstrated by the appearance of reducing sugar, in tests in which the Somogyi-Nelson reagents are used (*6*). However, we have found that intestinal extracts of the sea urchin very quickly reduce the viscosity of algin solutions.

The presence of an alginase in marine animals and production of this enzyme by marine decomposing microorganisms may have considerable ecological significance in the economy of the intertidal and subtidal zones. Waksman *et al.* claim that bacteria are most important in algin decomposition and assign a negligible role to marine fungi (*7*).

A further importance of alginase may lie in its use in clarifying the structure of algin, which is known to be a linear polymer of mannuronic acid, although details of the structure are still not fully known (*8*). Miwa (*2*) used the enzyme from *Haliotus* in a study of the anatomy of brown algae.

Because algin is a major constituent of brown algae, which, at times, make up a large portion of the diet of *S. purpuratus,* our purpose was to examine this animal for the existence of an alginase and to determine whether such an enzyme is active at the reported *p*H of the gut.

Crude enzyme preparations were obtained from (i) whole gut plus gut contents; (ii) the gut wall, washed five times with sterile sea water; (iii) the liquid gut contents; and (iv) the solid contents of the gut (in this case mostly coralline red algae). The filtered gut liquid contents were used directly. The other preparations were ground in a mortar with cold 0.5*M* tris buffer (tris-hydroxymethylaminomethane) at *p*H 7.5, then filtered through Whatman No. 1 and No. 42 filter papers before use.

These extracts were mixed with approximately 0.1 percent of sodium alginate (*9*), and subsequent changes in viscosity were followed by means of a rolling ball (Hoeppler type) viscosimeter. Decrease in viscosity was taken as evidence for digestion of the algin (*2*).

For the determination of activity with varying *p*H, tissues were ground in distilled water and filtered as before, then mixed with alginate made up in the appropriate buffer. Variation in the initial algin viscosity, especially marked in McIlvaine's buffers, was corrected for in the activity determinations. The digestion experiments never exceeded 4 hours' duration, and no preservative was used.

Potassium oxalate (final concentration 0.03 percent) was added to the gut liquid and gut solids extracts to eliminate the effects of calcium salts (from the coralline red algae) on the viscosity of the algin solutions. The same amount of oxalate, added to extracts low in calcium, was without effect on the enzyme activity.

Tests for reducing-sugar production during the reaction period were made by the Somogyi-Nelson method (*6*). Tests for mannuronic acid were made on aliquots, after precipitation of polyuronides with 10 percent calcium chloride, in a naphthoresorcinol test (*10*).

All of the extracts appeared to contain an enzyme or enzymes capable of digesting algin. At the same time, no increase in reducing sugar could be demonstrated, nor did any calcium-soluble, naphthoresorcinol-positive products appear. Only the marked decreases in viscosity observed indicated that digestion had occurred. Again, by analogy with pectic enzyme nomenclature, this alginase may be called an algin depolymerase.

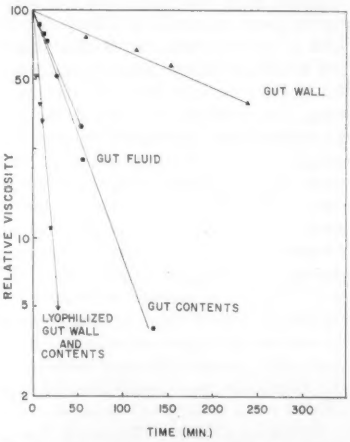

Fig. 1. Reduction in viscosity of sodium alginate solution in the presence of alginase extracts from the sea urchin *Strongylocentrotus purpuratus.* Relative viscosity = (100 minus percentage of viscosity change). Reaction mixtures contained: (i) gut fluid, gut solids, and gut wall; (ii) 3 ml of extract, 14 ml of 0.1-percent sodium alginate, and lyophilized gut wall and contents; (iii) 10 ml of extract, 20 ml of sodium alginate.

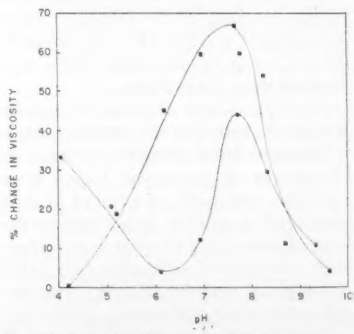

Fig. 2. Activity-*p*H curves for *S. purpuratus* gut wall and gut contents (squares) and gut wall (circles). Tris buffer was used for *p*H 7.5 and above; McIlvaine's buffer, for *p*H 7.5 and below. Reaction mixtures contained: (i) gut wall and gut contents; (ii) 4 ml of enzyme preparation, 5 ml of buffer, 10 ml of 0.1-percent sodium alginate, gut wall; (iii) 1.5 ml of enzyme preparation, 5 ml of buffer, 11 ml of sodium alginate. Reaction period, 30 min.

The gut wall was less active than were the liquid contents, the gut solid extracts, or the combined gut contents and gut wall, containing approximately the same concentration of homogenate. The most rapid digestion of algin occurred with a lyophilized gut-wall-plus-gut-contents preparation. This extract decreased the viscosity of the polysaccharide by more than one-half in 7½ min, and the reduction in viscosity was complete in 50 min (Fig. 1).

Figure 2 shows the *p*H activity curve for the alginase of the gut wall compared with that of the pooled gut wall and gut contents. Although both have optima in the range of the intestinal *p*H (7.2 to 7.3) (*11*), the alginase from the gut wall has an additional optimum toward *p*H 4 (*p*H values below 4 were not used because of the increase in algin viscosity at low *p*H).

Different *p*H activity curves, obtained for the alginase of the gut wall and of the gut contents, respectively, suggest that there may be two alginases involved. Because the gut contents of this animal are known to contain microorganisms capable of degrading whole brown algal blades (*5*), it is possible that these may be a source of alginase in the gut. On the other hand, precursors of alginase in the gut wall could contribute to the alginase found in the gut contents. Clarification of the role of intestinal bacteria in algin digestion by *Strongylocentrotus purpuratus* is needed. It would also be of interest to characterize the products of algin digestion by these preparations and to determine their usefulness to the sea urchin.

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15 September 1958

Functional Hermaphroditism and Self-fertilization in a Serranid Fish

Abstract. Each mature individual of *Serranellus subligarius*, regardless of size, has at the same time both motile sperm and eggs. Embryos and larvae were produced from artificial fertilizations and from isolated fish kept in aquaria. Mating behavior of pairs and groups of hermaphrodites shows two types of behavioral patterns involving different color changes.

Although teratological hermaphroditism has been reported in a wide variety of teleosts, only two groups, the serranids and the sparids, have been seriously considered to have members which are regularly and functionally hermaphroditic. Evidence for this has been based on purely anatomical and similar evidence. A recent review of this situation is given by Bertin (*1*). The present report presents data on the reproductive behavior, including self-fertilization, of the serranid *Serranellus subligarius* (Cope) (*2*). Such observations were possible because this species is small enough to be kept conveniently in the usual laboratory aquaria.

During July, August, and early September of 1958, all of the mature individuals of this species appeared to have slightly to greatly distended abdomens. They are common in depths of from 8 to 65 ft on rocky bottoms in areas of the Gulf of Mexico near the Cape Haze Marine Laboratory, off Sarasota and Madeira Beach, Florida, where I have observed thousands of these fish while skin diving. Over two hundred specimens have been collected by steering them into glass jars by hand (*3*). Individuals over 28 mm in standard length which were examined had sizable ovaries with a thin winding patch of white tissue, on the ventral surface, from which motile sperm smears can be made. Within 1 or 2 days after they have been collected, greatly distended individuals can be made to release quantities of mature sperm and hundreds of ovulated eggs simultaneously by means of very slight pressure on the abdomen. If this pressure is applied while the genital area of the fish is being viewed under a dissecting scope it can be seen clearly that the eggs are released from a separate exit of the oviduct into a small vestibule under a flap with a bilobed edge, just posterior to the anus. Posterior to the exit for the ova is a pigmented genital papilla which erects slightly when sperm is released from a small opening at the tip of the papilla. A clear fluid is sometimes released with the cloud of sperm. Eggs have been artificially fertilized by sperm from the same individual by washing both eggs and sperm from the genital area into a fingerbowl with sea water. Ovulated eggs in good condition taken from live or recently dead fish are readily fertilized by sperm from the same or another fish.

In cases of both self- and cross- artificial fertilizations, embryonic development has been followed through to the hatching of the larvae (18 to 22 hours at 82 to 88°F). The egg is buoyant and nonadhesive and has a single oil drop. The developing embryo and newly hatched larva have a distinctive set of round dark pigmented areas (two on the head, two just anterior to the anus, and four forming a ring around the tail, halfway along its length).

I have observed spawning activity in nature while diving with an Aqualung, and also in laboratory aquaria. Studies so far indicate that spawning activity usually takes place between two individuals in the late afternoon between 4 and 7 P.M. It seems to be initiated by a fish with a distended abdomen, who puts its body into an "S" curve, spreading its fins and sometimes quivering in this position directly before or near the head end of another fish. During S-curving the white area of the abdominal region stands out conspicuously. The other fish may be obviously carrying ripe ova as well as sperm, or it may be comparatively slim, carrying only immature ova but with sperm which can be squeezed out easily. A fish with only mature sperm will often ignore an S-curving fish or nip it and show aggressive behavior toward it. In other cases it will start to follow an S-curving fish until both fish are swimming with slow jerky movements, often upwards to the surface of the aquarium, and the pairing fish may separate momentarily or for long periods after a splash at the surface. In nature, however, the fish stayed within a few inches of the bottom on the occasions when they showed spawning behavior. The fish that is following often touches with its mouth the dorsal region of the S-curving fish, or it may follow from below and gently mouth the abdominal region. Sometimes the S-curving fish will lie down on its side with the other fish curved over it.

As S-curving activity becomes more marked, being repeated at more frequent intervals, and while the fish are close together, there is a noticeable color-pattern change in the S-curving fish. The fish blanches, the usual dark vertical bands on the sides of the body completely disappear, and the large black spot at the base of the dorsal fin suddenly turns pale gray. In addition, the evenly rounded profile of the abdomen changes, and the front half is pulled up flatter while the posterior part of the abdomen is lowered conspicuously and sharply just anterior to the genital area, forming approximately a right angle with the genital area. The other fish of the pair stays in the normal darker-banded color phase, and only in a few instances is there

noticeable blanching of the dorsal-fin spot, although, if this is also a distended fish, it may show the same change in the abdominal profile.

In some observations on group behavior in large aquaria a blanched, S-curving fish has aroused a response from as many as five other banded individuals. Although usually only one or two banded fish are able to hold a position close to the S-curving fish, in several instances all six of these fish rushed to the surface in a tight group and made a splash, the body of the blanched fish being strongly arched. Occasionally a rotund but banded fish, especially in a group showing this behavior, will suddenly reverse its role, blanch, and start S-curving and behaving like a typically blanched fish. This may last for only a few seconds or continue into typical spawning behavior with a banded fish. On some occasions both fish of a spawning pair may reverse roles for short periods, with intervals when both fish are blanched and S-curving. Usually the more distended fish will S-curve more strongly and more continuously, in an aggressive manner, blocking off and cornering the other blanched fish until it returns to the banded condition.

Spawning activity among pairs or groups may keep up for more than an hour, and water-surface samples taken afterwards show hundreds of fertilized eggs in various stages of early cleavage. However, the exact moment when eggs and sperm are released has yet to be determined with certainty, as there appear to be no special times when the genital areas of the fish are very close together. Also, it is not known which fish releases eggs and which sperm, or if eggs and sperm are released together from one or both fish. It was at first suspected that the blanched fish was releasing eggs and the banded fish, sperm, but subsequent observations have shown that an obviously gravid fish will blanch and go through S-curving and quivering movements and, without any response from another fish, release eggs and sperm that produce embryos and larvae even when such a fish is kept in isolation. In two instances the eggs could be seen coming out of the fish shortly after some quivering movements and a lowering of the post-abdominal region; the fish then seemed to rest on the bottom. There is also evidence that the mere sight of another fish in an adjacent aquarium could stimulate this release. Greatly distended fish caught in the morning and kept isolated will often release nonfertile or self-fertilized eggs the same or the following day. This may well be an artificial response brought about by laboratory conditions and the separation of natural pairs just before they are ready to spawn. A comparison of the sizes of these fish with the state of their gonads has given no evidence, so far, of a protandric condition with an intermediate stage to explain individuals capable of self-fertilization.

In nature these fish are strongly territorial. Before June, skin-diving observations indicated that only one mature-sized fish of this species occupied a territory (usually a ledge or pathway among the rocks). But in June and more frequently in July, pairs and sometimes trios of large fish with distended abdomens shared the same pathways, indicating a tolerance to sharing the same territory. This is especially noticeable because of the manner in which we catch these fish. By chasing them a few times around the rocky ledges, a diver can soon estimate the extent of their territory and can determine what other fish share this territory (such as *Opsanus, Equetes, Pomacentrus* and various species of gobies and blennies, and *Hypleurocheilus geminatus,* the last of which forms a substantial part of the diet of *Serranellus*).

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2. Details of the gross anatomy and histology of the reproductive system, as well as details on the embryonic development and spawning observations, are in preparation. This study has been greatly helped by the valuable suggestions and criticisms of Dr. C. M. Breder, Jr.
3. I am grateful to P. Bylaska, O. Farver, J. Hamlin, J. Randall, and T. Romans for their aid in collecting specimens.

18 August 1958

Hemoglobin Patterns in American Indians

Abstract. Two populations of North Carolina have been analyzed for hemoglobin patterns by paper electrophoresis. Of 534 Cherokee Indians, both mixed and full bloods, all showed normal hemoglobin. Lumbee Indians of less certain ethnic status had 1.7 percent of hemoglobin S, an equal amount of hemoglobin C, and one possible hemoglobin D trait among 1332 bloods studied.

Bloods of Cherokee and Lumbee Indians of North Carolina have been analyzed for hemoglobin patterns by the rapid paper electrophoresis method (*1*). All abnormal patterns were verified by standard electrophoretic techniques and sickle-cell tests.

The Cherokee Indian sample consisted of school children on the reservation at Cherokee, N.C. Among this Eastern band of the tribe, descended from those who escaped the forced westward migration of 1838, there is, as is known from the tribal records, a wide range of degree of Indian ancestry. No abnormal hemoglobins were found among 534 bloods studied, including 136 "full bloods."

The Lumbee Indians are a population in the south-central part of the state, whose origins are uncertain. Considering themselves primarily a mixture of Indian and white, they have also been known as Croatans and Indians of Robeson County. The sample studied consisted of students in Pembroke College, High School, and Elementary School. Of 1332 bloods analyzed, 23 (1.7 percent) showed sickle-cell trait (A plus S), and an equal number exhibited hemoglobin C trait (A plus C). One possible case of hemoglobin D trait (A plus D) requires further study for verification. No other abnormal hemoglobins were encountered.

Previous studies of American Indians have revealed no abnormal hemoglobins (*2*), but the claim of Indian ancestry among many individuals with hemoglobin D suggested the likelihood of a reservoir of such abnormal hemoglobin among Indian populations (*3*). Furthermore, two non-Indian families in the same general geographic area as the Lumbee Indians had shown hemoglobin D (*4*). The present survey suggests the absence, or extremely low incidence, of abnormal hemoglobins among unmixed American Indians (*5*).

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5. A report on the results of blood typing conducted on the same blood samples, along with an anthropological analysis, is in preparation. This work was supported by U.S. Public Health Service grant No. A-1615 and by grants from the Duke University Research Council and the United Medical Research Foundation of North Carolina.

25 August 1958

(*Continued from page 174*)

I agree with Carstater that the young scientist "should be concerned with both the scientific and managerial quality of the supervision he will receive." These are important considerations. A record of publication constitutes one type of evidence as to the caliber of the scientific output of a laboratory. The "managerial quality of supervision" is extremely difficult to evaluate unless one is personally involved in an organization.

I do not know what Carstater means by "the privilege of publishing." Publication is not a favor to be conferred upon good behavior. In my opinion, in discussing the publication of a research paper, the word *privilege* should be taboo. It is legitimate to ask a research director, "What is the policy of your organization regarding the publication of research results?" One should be guided by one's own ideals after an answer to that question is obtained. Verbal answers, no matter how sincere, may not be known to administrators who later may direct a man's work. Unless reduced to writing, "policy" can become a meaningless thing.

Carstater is ungracious in stating that "an undeserved slur on the perspicacity of senior scientists, research directors, and deans" was intended or implied in the thesis of "The lost legion" editorial. Selection, at best, is a difficult task. All evidence, even if remotely related to the problem, should be available for consideration before an appointment is made. A record of published research constitutes evidence. It should be used in conjunction with, and not as a substitute for, verbal reports on behavior, attitudes, and record searches. The published record of research most certainly would not constitute "the only acceptable, or even the best, evidence of his productivity as a scientist." But it would be an important item for consideration.

I am slightly amused by but very tolerant of Carstater's "father knows best" point of view. He refers to "the immature scientist" and the scientist at a "more mature stage." There may be organizations where the research administrator "is likely to be mentor, counselor, and friend, seeking to develop and nurture whatever aptitudes are present." It would be interesting to conduct attitude surveys to check this hypothesis.

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Skin Diving in Rocket Ships

A person in a tank of water is able to withstand relatively great accelerations without damage or malfunction (even more than in a pilot's "G suit"). This could possibly be expected from the report on weightlessness by H. J. Muller [*Science* **128**, 772 (1958)].

Experiments demonstrating this were described to me by Carter Collins, about the time of the publication of my report "Some principles of self-contained underwater breathing apparatus" [*Science* **128**, 1001 (1958)]. Collins noted that an air-pressure regulator which is wrongly positioned with respect to the body is dangerous in high-acceleration situations because the density of the material separating the lungs and the regulator is effectively increased proportional to the acceleration, and thus the lungs are not necessarily supplied with air at the pressure surrounding them. The weight-compensated regulator described in my report effectively puts the regulator within the lungs, and it retains this ability under the action of most commonly experienced acceleration forces, whether compensation is by a weight or by a float. In a centrifugal field, if the center of rotation is near the person, departures from exact compensation can exist. Under changes in gravity, compensation in all positions can remain perfect. Compensation with a spring does not give these effects.

In this connection, it is relevant to

note that some early tests to determine the best location of a regulator (which indicated a location within the lungs) involved diving in a medium more dense than water and moving the regulator up or down to the most comfortable position relative to the body. An acceleration field effectively increases the density of the liquid and the compensating weight at the same rate, and so the required weight does not change as it would have to for diving in a different medium.

The concept of a "center of pressure" for the lungs, at which a regulator should effectively be positioned, probably loses much of its significance if a great pressure difference exists across the chest itself. (For example, one might expect difficulty in trying to breathe under mercury.)

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Strontium Content of Human Bone

In the issue of 1 August [*Science* **128**, 256 (1957)], Thurber, Kulp, Hodges, Gast, and Wampler report on their measurements on the common strontium content of human bones from urban populations. They deduce a ratio of Sr to Ca in bone of $(0.45 \pm 0.1) \times 10^{-3}$. Combining this with the figure they quote for the same ratio in average soil, one obtains a discrimination factor of 16 ± 4, which has a significantly higher error than they quote.

This perhaps makes less disturbing the discrepancy between their measured discrimination and the one which can be calculated on the basis of the discrimination factors they quote for the various biological systems. Using these numbers—namely, human calcium half derived from vegetation and half from milk, plant-to-soil discrimination equal to unity, plant-to-milk discrimination equal to 7, and milk or vegetation to human bone discrimination equal to 4—one estimates the over-all discrimination between soil and human bone to be about 7 (not 16 as quoted in the report). A discrepancy of a factor of 2 is perhaps not surprising in view of the roughness of the numbers and the simplifying assumptions which have been made.

The factor of 16 ± 4 is certainly an encouraging sign, but its relative constancy in these measurements, as Thurber *et al.* point out, is largely a function of the averaging of food sources in a modern urban environment. It would be interesting to see similar measurements on bones from isolated rural populations in calcium-rich and calcium-deficient regions.

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Meetings

Sensory Deprivation

A "Symposium on Sensory Deprivation" was held at Harvard Medical School in Boston on 20 and 21 June 1958. The meeting was jointly sponsored by the Physiological Psychology Branch of the Office of Naval Research, the Harvard Medical School, and the Boston City Hospital. The meeting consisted of a working group of some 80 scientists working directly or indirectly with problems of sensory deprivation, isolation, and confinement.

An outstanding feature of the meeting was the fact that representatives of a wide variety of disciplines and interests, ranging from neurophysiology, psychiatry, psychoanalysis, and psychology to biochemistry, pharmacology, mathematics, and engineering, could meet together and communicate meaningfully about a problem of common interest.

Sensory deprivation is the term applied to various experimental techniques designed to isolate the subject from his natural environment through the elimination, reduction, or stereotyping of sensation from vision, hearing, and touch. The effects of sensory deprivation have long been known in the accounts of explorers and shipwrecked sailors, more recently in "brainwashed" prisoners-of-war. They are varied and include boredom, restlessness, oppression, mental inefficiency, and aberrations in thinking. The specific determinants and consequences of sensory deprivation have recently come in for increasing systematic study in the laboratory.

Findings were reported at the symposium relevant to the effects of deprived or restricted environments upon intellectual function, opinions and attitudes, perceptual performance, reaction time, electroencephalograms, and physiological reactivity, as well as upon personality and emotions. The relevance of sensory deprivation to a variety of practical situations was examined, including its role in the treatment of psychiatric disorders, its effects on the performance of aviators, and its special utility in the study of stress. The particular relevance of questions raised by research in sensory deprivation for concepts, techniques, and theory in psychoanalysis was also discussed.

The mental disturbances produced by sensory deprivation were thought to be explained best in terms of interference with previously little understood neural mechanisms essential to alertness and attentiveness. The mind does not seem to function efficiently without constant contact with changing stimuli from the outside world. On the other hand, effects similar to those seen with sensory deprivation have been observed in situations

in which this same neural mechanism is taxed through overloading.

On the behavioral level it was suggested that decrease in environmental input (in terms of either absolute reduction or absence of change) has the effect of modifying the learned model of the world which each individual acquires in the form of expectancies or "programs" for dealing with reality. The understanding of the results of sensory deprivation clearly requires a functional, rather than a structural, view of behavior and its instrumentalities.

The classical conception of the human nervous system as essentially a switching mechanism appears increasingly to be losing ground. In its place has emerged a view of the nervous system, as characterized by W. Gray Walter, as a "complex, probabilistic, nonlinear system." This change in perspective has produced new emphases in research. For example, the previous total input-output history of the experimental organism, hitherto ignored, has become an important variable to be controlled. The functional view also points to a search for the parameters of sensory input along "meaning" dimensions as well as along physical dimensions for understanding resultant output or behavior.

The symposium included six papers reporting completed work, three theoretical papers, and a round-table discussion. The experimental papers were as follows:

1) "Cognitive and physiological effects of perceptual isolation," by Woodburn Heron.

2) "Individual differences in reaction to experimental interference with reality contact," by Leo Goldberger and Robert R. Holt.

3) "The effect of human isolation upon some perceptual and motor skills," by Jack Vernon, Thomas E. McGill, Walter Gulick, and Douglas K. Candland.

4) "Sensory deprivation in aviation," by A. M. H. Bennett.

5) "Physiological and psychological aspects of sensory deprivation—a case analysis," by Jack H. Mendelson, Philip Kubzansky, P. Herbert Leiderman, Donald Wexler, and Philip Solomon.

6) "Observations of anaclitic therapy during sensory deprivation," by Hassan Azima, R. Vispo, and Fern J. Azima.

The theoretical papers discussed sensory deprivation from the point of view of psychoanalysis, neurophysiology, and cognitive psychology, as follows:

1) "Theoretical considerations," by Lawrence S. Kubie.

2) "Are there common factors in sensory deprivation, sensory distortion and sensory overload?" by Donald B. Lindsley.

3) "The cognitive consequences of early sensory deprivation," by Jerome Bruner.

A concluding round-table discussion was held, with the following participants: Donald O. Hebb, Jerome S. Bruner, Ernst Gellhorn, Lawrence S. Kubie, John C. Lilly, Erich Lindemann, Donold B. Lindsley, Horace G. Magoun, W. Gray Walter, Norbert Wiener, and Heinz Werner. Among others who contributed significantly to the general discussion were Grete Bibring, Edwin Boring, Enoch Callaway III, Sanford I. Cohen, Joel Elkes, Charles Fisher, Robert Grenell, George Klein, Warren McCulloch, Sydney Margolin, Austin Riesen, Norman Rosenzweig, George Ruff, and Richard Trumbull.

The proceedings of the meetings are to be published.

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Forthcoming Events

February

23–27. American Concrete Inst., 55th annual, Los Angeles, Calif. (W. A. Maples, A.C.I., 18263 W. McNichols Rd., Detroit 19, Mich.)

25–26. Midwest Industrial Radioisotopes Conf., Manhattan, Kan. (J. Kitchens, Dept. of Continuing Education, Kansas State College, Manhattan.)

25–27. Biophysical Soc., annual, Pittsburgh, Pa. (G. Felsenfeld, Dept. of Biophysics, Univ. of Pittsburgh, 325 Clapp Hall, Pittsburgh 13.)

26–28. American Acad. of Forensic Sciences, annual, Chicago, Ill. (W. J. R. Camp, AAFS, 1853 W. Polk St., Chicago 12.)

26–28. Genetics and Cancer, 13th annual symp. on fundamental cancer research, Houston, Tex. (Editorial Office. Univ. of Texas, M. D. Anderson Hospital and Tumor Inst., Texas Medical Center, Houston 25.)

27–1. National Wildlife Federation, 23rd annual convention, New York, N.Y. (NWF, 232 Carroll St., NW, Washington 12.)

March

1–2. Pennsylvania Acad. of Sciences, Gettysburg. (K. Dearolf, Public Museum and Art Gallery, Reading, Pa.)

1–5. Gas Turbine Power Conf., Cincinnati, Ohio. (O. B. Schier, ASME, 29 W. 39 St., New York, N.Y.)

7. American Chemical Soc., Oklahoma Div., tetrasectional meeting, Tulsa. (J. W. Conant, ACS, Grand River Chemical Div. of Deere and Co., Pryor, Okla.)

8–9. American Broncho-Esophagological Assoc., Hot Springs, Va. (F. J. Putney, 1712 Locust St., Philadelphia, Pa.)

8–9. American Laryngological Assoc., Hot Springs, Va. (J. H. Maxwell, University Hospital, Ann Arbor, Mich.)

8–12. Aviation Conf., Los Angeles, Calif. (O. B. Schier, ASME, 29 W. 39 St., New York, N.Y.)

10–12. American Laryngological, Rhinological and Otological Soc., Hot Springs, Va. (C. S. Nash, 708 Medical Arts Bldg., Rochester 7, N.Y.)

13–14. American Otological Soc., Hot Springs, Va. (L. R. Boies, University Hospital, Minneapolis 14, Minn.)

13–15. Alabama Acad. of Sciences, Auburn, (H. M. Kaylor, Dept. of Physics, Birmingham-Southern College, Birmingham, Ala.)

14–15. Southwestern Soc. of Nuclear Medicine, 4th annual, New Orleans, La. (S. B. Nadler, SSNM, 1520 Louisiana Ave., New Orleans 15, La.)

15–20. American College of Allergists, San Francisco, Calif. (M. C. Harris, 450 Sutter St., San Francisco.)

16–19. American Assoc. of Petroleum Geologists, Soc. of Economic Paleontologists and Mineralogists, 44th annual, Dallas, Tex. (W. A. Waldschmidt, AAPG, 311 Leggett Building, Midland, Tex.)

16–20. American Inst. of Chemical Engineers, Atlantic City, N.J. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36.)

16–20. National Assoc. of Corrosion Engineers, 15th annual conf., Chicago, Ill. (NACE, Southern Standard Bldg., Houston, Tex.)

16–20. Western Metal Exposition and Cong., 11th, Los Angeles, Calif. (R. T. Bayless, 7301 Euclid Ave., Cleveland 3.

17–19. National Health Council, Chicago, Ill. (P. E. Ryan, 1790 Broadway, New York, 19.)

18–25. International Social Science Council, 4th general assembly (by invitation), Paris, France. (C. Levi-Strauss, Secretary-General, International Social Science Council 19, avenue Kleber, Paris.)

19–21. Society for Research in Child Development, NIH, Bethesda, Md. (Miss N. Bayley, Laboratory of Psychology, National Inst. of Mental Health, Bethesda 14, Md.)

23–26. Institute of Radio Engineers, natl. conv., New York, N.Y. (G. L. Haller, IRE, 1 E. 79 St., New York 21.)

24–27. American Meteorological Soc., general, Chicago, Ill. (K. C. Spengler, AMS, 3 Joy Street, Boston, Mass.)

27–28. Michigan Acad. of Sciences, East Lansing. (D. A. Rings, Univ. of Michigan, Dept. of Engineering, Ann Arbor.)

28. South Carolina Acad. of Sciences, Columbia. (H. W. Freeman, Dept. of Biology, Winthrop College, Rock Hill, S.C.)

29–3. Latin American Congress of Chemistry, 7th, Mexico D.F., Mexico. (R. I. Frisbie, Calle Ciprès No. 176, Zone 4, Mexico, D.F.)

30–1. American Orthopsychiatric Assoc., San Francisco, Calif. (M. F. Langer, 1790 Broadway, New York 19.)

30–12. Bahamas Medical Conf., 7th, Nassau. (B. L. Frank, 1290 Pine Ave., W. Montreal, Canada.)

31–2. American Power Conf., 21st annual, Chicago, Ill. (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

31–2. Symposium on Millimeter Waves, 9th, New York, N.Y. (H. J. Carlin, Microwave Research Inst., 55 Johnson St., Brooklyn 1, N.Y.)

31–5. International Committee of Military Medicine and Pharmacy, 21st session, Paris, France. (Comité International de Médecine et de Pharmacie Militaires, Hôpital Militaire, 79, rue Saint Laurent, Liège, Belgium.)

April

1–3. American Assoc. of Anatomists, Seattle, Wash. (B. Flexner, Univ. of Pennsylvania Medical School, Philadelphia 4.)

1–4. National Council of Teachers of Mathematics, Dallas, Tex. (H. T. Karnes, Dept. of Mathematics, Louisiana State Univ., Baton Rouge 3.)

1–4. National Science Teachers Assoc., 7th natl. conv., Atlantic City, N.J. (R. H. Carlton, NSTA, 1201 16 St., NW, Washington 6.)

1–4. Neurosurgical Soc. of America, Hot Springs, Va. (F. P. Smith, 260 Crittenden Blvd., Rochester 20, N.Y.)

1–29. World Meteorological Organization, 3rd session of congress, Geneva, Switzerland. (WMO, Campagne Rigot, 1, avenue de la Paix, Geneva.)

2–3. Electrically Exploded Wires, conf., Boston, Mass. (W. G. Chace, Thermal Radiation Laboratory, CRZCM, Geophysics Research Directorate, Air Force Cambridge Research Center, Bedford, Mass.)

2–4. Association of American Geogra-

phers, 55th annual, Pittsburgh, Pa. (J. E. Guernsey, 9707 Parkwood Dr., Bethesda, Md.)

2–4. Association for Computing Machinery, Cleveland, Ohio. (J. Moshman, Corporation for Economic and Industrial Research, 1200 Jefferson Davis Highway, Arlington 2, Va.)

2–4. Optical Soc. of America, New York, N.Y. (S. S. Ballard, Dept. of Physics, Univ. of Florida, Gainesville.)

3–4. Eastern Psychological Assoc., Atlantic City, N.J. (C. H. Rush, Standard Oil Co. of New Jersey, Rockefeller Plaza, New York, N.Y.)

3–5. American Soc. for the Study of Sterility, Atlantic City, N.J. (H. H. Thomas, 920 S. 19 St., Birmingham 5, Ala.)

3–5. Cooper Ornithological Soc., Berkeley, Calif. (J. Davis, Univ. of California, Hastings Reservation, Jamesburg Route, Carmel Valley.)

5–9. American College of Obstetricians and Gynecologists, Atlantic City, N.J. (J. C. Ullery, 15 S. Clark St., Chicago 3, Ill.)

5–10. American Chemical Soc., 135th, Boston, Mass. (M. A. H. Emery, 18th and K St., NW, Washington, D.C.)

5–10. Nuclear Congress, Cleveland, Ohio. (S. Baron, Burns & Roe, Inc., 160 West Broadway, New York 13.)

6. Paleontological Research Institution, Ithaca, N.Y. (R. Harris, 109 Dearborn Rd., Ithaca.)

6–7. Chemical and Petroleum Instrumentation, 2nd natl. symp., St Louis, Mo. (H. S. Kindler, Director of Technical and Educational Services, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.)

6–8. American Radium Soc., Hot Springs, Va. (R. L. Brown, Robert Winship Clinic, Emory Univ., Atlanta 22, Ga.)

6–8. Astronautics, AFOSR 3rd annual symp., Washington, D.C. (Headquarters, Air Force Office of Scientific Research, Washington 25.)

6–8. National Open Hearth Steel Furnace, Coke Oven and Raw Materials Conf., St. Louis, Mo. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

6–9. American Acad. of General Practice, San Francisco, Calif. (M. F. Cahal, Volker Blvd. at Brookside, Kansas City 12, Mo.)

6–11. Coordination Chemistry, intern. conf., London, England. (Chemical Soc., Burlington House, London, W.1.)

12–13. American Soc. for Artificial Internal Organs, Atlantic City, N.J. (C. K. Kirby, ASAIO, 110 Maloney Bldg., University Hospital, 3600 Spruce St., Philadelphia 4, Pa.)

12–16. American Physiological Soc., Atlantic City, N.J. (R. C. Daggs, 9650 Wisconsin Ave., Washington, D.C.)

12–16. Fracture, intern. conf., Cambridge and Dedham, Mass. (Headquarters, Air Force Office of Scientific Research, Washington 25.)

13. Biochemical Cytology of Liver (Histochemical Soc.), symp., Atlantic City, N.J. (A. B. Novikoff, Dept. of Pathology, Albert Einstein College of Medicine, Yeshiva Univ., Eastchester Rd. and Morris Ave., New York 61.)

(*See issue of 16 January for comprehensive list*)

Equipment

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science *does not assume responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 230.*

■ SCINTILLATION PROBE for detection of fast or slow neutrons and gamma and beta radiation uses a ten-stage, ¾-in. multiplier photo-tube and a transistorized electronic circuit. The unit is water tight and corrosion proof. Resolution time is in the microsecond range. Accessories include a neutron probe 11/32-in. in diameter and three needle probes 2 to 6 mm in diameter. Wall thickness of the latter is 2.5 mil. (Nuclear-Chicago Corp., Dept. 593)

■ LABORATORY OVEN is designed to be explosion-proof. A dual safety control acts if the master temperature control fails. A limiting control will turn the oven off if a flash fire occurs or if the safety setting is reached. A rear blow-out panel protects personnel. Heaters are totally enclosed, and the interior is automatically ventilated before heaters are energized. Temperatures range up to 260°C and are controlled to ± 0.8°C. (Modern Laboratory Equipment Co., Dept. 599)

■ DETECTOR-INTEGRATOR measures random noise over the frequency range 10 cy to kcy/sec with dynamic range better than 50 db. Output is proportional to the average value of the input. Limits of interval of integration from 0.5 to 60 sec can be provided. Output is read on a panel meter. Low-impedance punched-card, punched-tape, or other data-storage outputs are available. (Chesapeake Instrument Corp., Dept. 583)

■ KERR-CELL SHUTTER, for ultrahigh-speed photography, permits incorporation of any exposure time from 0.1 to 0.01 μsec on a particular shutter. The shutter incorporates a Kerr cell 2 in. in diameter, a pulse generator, and a spark-gap device. The unit operates from an external 60-kv source and a low-voltage trigger source. Transmission of the cell is approximately 7 percent, and transmission ratio 20,000 to 1. The cell is hermetically encased. (Avco Manufacturing Corp., Dept. 606)

■ CONDUCTIVITY CELLS for use as laboratory standards against which "working" conductivity cells may be checked are available with cell constants 0.01, 0.1 and 1. They may be used for immersion of flow measurements. (Industrial Instruments, Inc., Dept. 600)

■ HOTPLATE AND MAGNETIC STIRRER combination provides three heat positions and variable stirring. Maximum hot-plate power is 750 w. The plate is designed so that its stainless-steel case remains cool. Teflon stirring bars are supplied. (E. H. Sargent & Co., Dept. 602)

■ CHECK VALVE of silicone rubber is mounted in a standard 1.5-in. needle adaptor to permit administration of drugs, fluids, and gases in cardiovascular and renal studies. The device will open under pressure of less than 6 cm-H_2O and will withstand 500 cm of back pressure. The valve may be autoclaved or sterilized in zephrine. (T. H. Heyer, Dept. 598)

■ PRODUCTION-OPERATIONS RECORDER, operated by electrical impulses from any contact device counts the number of units produced during any preselected time interval. The counts are permanently recorded on punched paper tape suitable for use with automatic data-processing machines. A cumulative total is also presented. Standard time intervals are 5, 15, 30, or 60 min. Other intervals are available. (Fischer and Porter Co., Dept. 608)

JOSHUA STERN
National Bureau of Standards

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Bacteriologist, B.S. (chemistry); M.S. (physiology major; Ph.D., (bacteriology major; mycology minor); 9 years, chief bacteriologist, large teaching hospital; on faculty medical school as instructor. Medical Bureau, Burneice Larson, Director, 900 North Michigan, Chicago. X

Virology-Tissue Culture, D.V.M., Ph.D., 34, excellent experience human and animal viruses. Experimental pathology, cancer. Desires change. Box 9, SCIENCE. 1/23

Zoologist, Ph.D., 10 years of teaching experience. Numerous publications. Box 7, SCIENCE. 1/23

POSITIONS OPEN

Applications are invited for the position **Assistant Professor of Biology** to give instruction in physiology, embryology, and histology. Opportunities for research are available. The salary scale is $5400–$7000. A contributory pension scheme is in operation. Moving expenses are payable by the university to a maximum of $750. Applications containing a complete curriculum vitae and the names and addresses of three referees should be sent to the Head, Department of Biology, Memorial University of Newfoundland, St. John's, Newfoundland. 1/23, 30

Biologist to head scientific staff of growing, established biological supply house. Field collecting experience, plus knowledge of preserving and other biological techniques necessary. Ph.D. degree desired. Administrative ability and teaching experience required. Paid vacations, holidays, benefits, salary opportunities. Box 8, SCIENCE. 1/23, 30; 2/6

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Physiologist, Psychologist, and Physicist, Ph.D. or M.S. with appropriate experience. Strong research orientation required. To join a rapidly expanding Human Factors and Space Psychophysiology Group. Research presently undertaken by the group covers the fields of perception, human transfer functions, motor response dynamics, analyses of man as a component in complex weapon systems, animal performance in simulated space flight conditions, and other studies related to both conventional and space type weapon systems. Salary will parallel experience and demonstrated achievement. Please send résumé to Mr. C. G. Jones, Manager, Salary Personnel, Goodyear Aircraft Corporation, 1210 Massillon Road, Akron 15, Ohio. 1/23

POSITIONS OPEN

GOVERNMENT OF NEW ZEALAND
Vacancy for **Director, Institute of Nuclear Sciences,** Department of Scientific and Industrial Research, Wellington. Commencing salary will be fixed between £1840 and £2440 per annum (allowance to £2500 if merited) depending on qualifications.

Qualifications desired: Proven scientific ability in a field of nuclear sciences, such as radiochemistry, nuclear physics, isotope techniques, or theoretical physics. An interest and proven ability in using such fields of work to solve a wide range of scientific and applied problems.

Duties: To lead a research team of about 40 scientists and carry out administrative duties therewith. The Director will be required to collaborate with university staff working at the Institute. It must be pointed out that the Institute will not be undertaking major work in reactor technology and that its concern will be the peaceful uses of atomic energy of value to industry, agriculture, and so forth, and research problems generally.

Further details and forms of application may be obtained from the New Zealand Embassy, 19 Observatory Circle, NW, Washington 8, D.C. Applications close in Washington on **27 February 1959.** X

(a) Physician to direct section of intravenous fluids and electrolyte balance, department of clinical investigation, major company; excellent training in surgery, pediatrics or anesthesiology desirable; $15,000; Midwest. **(b) Research Director;** top management position reporting directly to president; staff of 20 graduate-level people engaged in research; Ph.D. with extensive experience in pharmaceutical field and record of achievement in original thought either through patents or scientific papers required: $13,000–$18,000; Midwest. **(c) Clinical Microbiologist, Physician or Ph.D. Bacteriologist;** duties include supervision of clinical bacteriology and research; one of country's leading clinics and teaching hospital. S1-4 Medical Bureau, Burneice Larson, Director, 900 North Michigan, Chicago. X

POSITIONS OPEN

Pharmaceutical Product Development. Challenging position, in New York area. Proved background for full responsibility of new product development, contact with clinical investigators, and so forth; growing company. Reply should include record of product development and salary level. Box 5, SCIENCE. 1/16, 23

Postdoctoral Traineeship in Neuropharmacology Available for the Ph.D. in chemistry, biochemistry or pharmacology or the M.D. who would like to broaden his training and enter research in neuropharmacology. Stipends from $4500 per year and up plus dependent allowance. Postdoctoral fellowships in other areas, such as biochemical pharmacology, antibiotics, energy and drug enzymology, are also available. Write Chairman, Department of Pharmacology, Washington University School of Medicine, St. Louis 10, Missouri. 1/9, 16, 23, 30, 2/6

SCIENCE AND ENGINEERING AT ROBERT COLLEGE OF ISTANBUL

Opportunities at Robert College in Istanbul, Turkey for qualified men in engineering, mathematics, physics and chemistry interested in combining teaching and consulting with the opportunity to live and travel in a vital part of the world. Development program is in effect to strengthen staff, modernize undergraduate curricula, inaugurate graduate program, construct new science and engineering building, prepare engineers for the industrial and technological development of Turkey and the Middle East. A challenging work with far-reaching possibilities.

Address inquiries to Dr. Duncan S. Ballantine, President, or Dean Howard P. Hall of the College of Engineering at Robert College, Bebek P.K. 8, Istanbul, Turkey with copy to the Near East College Association, 40 Worth Street, New York 13, New York.

SCIENCE TEACHERS, LIBRARIANS, ADMINISTRATORS urgently needed for positions in many states and foreign lands. Monthly non-fee placement journal since 1952 gives complete job data, salaries. Members' qualifications and vacancies listed free. 1 issue, $1.00. Yearly (12 issues) membership, $5.00. CRUSADE, SCI., Box 99, Station G, Brooklyn 22, N.Y. ew

The Zoology Department, University of Alberta, invites applications for three posts. Applicants must hold a Ph.D. degree in zoology; recent graduates as well as those with postdoctoral experience will be considered. The starting salary will be $6000 to $8500 depending upon qualifications. A recent Ph.D. with no other experience would normally begin at the $6000 level.

Two of the appointments will be held at the University of Alberta in Edmonton. For these the zoology department is primarily interested in experimental embryologists, mammalogists, ethologists, parasitologists, cytologists, and cellular physiologists.

The third appointment will be to the University of Alberta in Calgary. At present teaching in Calgary is directed by the University in Edmonton. The department of zoology in Calgary is expected to become independent within a few years, and the appointee there will be expected to take a major share in planning and development. The field of specialization for this appointment is a secondary consideration.

Appointments begin 1 September 1959 and become permanent after 2 years of mutual satisfaction.

Applications should be addressed to Dr. D. E. Smith, Dean, Faculty of Arts and Science, University of Alberta, Edmonton. They should include a complete curriculum vitae, transcripts of university records, a photograph, and the names of at least three persons who have agreed to send references. Applications will be received until 1 April 1959. 1/23

FELLOWSHIPS

Research Fellowships in biochemical pharmacology are available for qualified individuals to study for Ph.D. degrees. A background in chemistry is desirable. Stipends begin at $1800 per year, plus dependent allowance. Write Chairman, Department of Pharmacology, Washington University School of Medicine, St. Louis 10, Missouri. 1/9, 16, 23, 30; 2/6

Announcing University of Louisville Fellowships in Biochemistry for 1959–1960. Predoctoral stipends $1800–$2200 annually, tax-free, tuition paid. Dependency and travel allowances as required. Applications should be submitted by 15 February 1959. Also postdoctoral fellowships; apply any time. Write Chairman, Department of Biochemistry, University of Louisville School of Medicine, 101 West Chestnut Street, Louisville 2, Kentucky, for application. 1/23

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POSITIONS OPEN

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In list below, check page number of advertiser from whom you would like more information. If more than one item appears in ad, letters (A, B, C) are used to indicate particular items available in order of appearance in advertisement. Where more than one ad appears on page, **"U" indicates upper ad, "L" lower ad, "I" inside ad, "M" middle ad,** and **"O" outside ad.** Advertisements in Personnel Placement and Market Place are not keyed. A multiplicity of items is indicated by *. Readers are requested to specify on this coupon the particular item in which they are interested; otherwise, the request cannot be processed.

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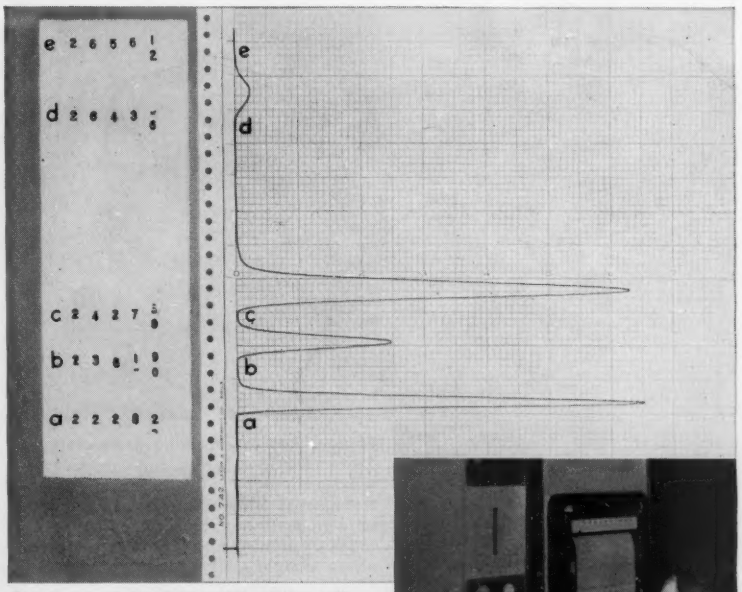
Now...automatic printed integration of chart peak areas

Perkin-Elmer's new Model 194 presents 6000-count/minute integrals on adding machine tape, ready for interpretation



Fractogram of four-component mixture with integrator tape run in synchronous mode. The synchronous tape feed permits easy identification of integral prints with the corresponding peaks on the fractogram. Corresponding prints and printing points on the fractogram are identified by letters (a, b, c, d and e).

Integrals for each peak are obtained by subtracting the value printed at its leading edge from that printed at the leading edge of the next peak. Thus,
Propane = (b − a) = 23619 −22282 = 1337
Isobutane = (c − b) = 24278 −23619 = 659
n-Butane = (d − c) = 26436 −24278 = 2158
Isopentane = (e − d) = 26561 −26436 = 125

Concentrations for each component are computed by dividing the integral for its peak by the total integral (after applying thermal conductivity correction factors if necessary). The complete analysis of this mixture is:
Propane . . . 31.3%; Isobutane . . . 15.4%;
n-Butane . . . 50.4%; Isopentane . . . 2.9%.

Up to now, there have been four conventional methods of integrating the areas of peaks produced on a recorder chart by a gas chromatographic analyzer – for example:

FIRST: the time-consuming, error-prone approximation of measuring peak height and multiplying by half band width: only as accurate as the analyst's eye and scale at best, not valid for some peak shapes, and requiring a good deal of computation.

SECOND: so-called "pip" integration –using an auxiliary pen which dithers along the chart edge as the peak is recorded and the integrator counts (with each group of ten counts marked by a wider pen swing to facilitate counting). The disadvantages of this technique: low count rate/lower accuracy, with the inherent mechanical difficulties of "pip" recording by pen. You also have to count the pips!

THIRD: digital counter read-out – excellent integration, but demanding constant vigilance on the part of the operator to note dial readings at critical moments during peak elution.

FOURTH: planimeter area measurement, requiring a steady hand and virtually infinite patience – and not very accurate, either.

With Perkin-Elmer's new Model 194 Printing Integrator, designed for use with the P-E Model 154-C Vapor Fractometer, integrals are *printed* on standard adding machine tape, automatically at the base of each peak (or manually, on command) and in a variety of modes.

When the recorder pen begins an upscale excursion, a valley sensor in the recorder energizes the printing mechanism, and a five-digit integral is automatically printed on the tape. Tape and recorder chart move at the same speed, making later comparison and identification easy – or the tape can space evenly between prints. The next integral is automatically struck when the pen begins to record the next peak; the difference between this number and the first represents the area of the first peak. The last integral in an analysis is manually printed.

When the Model 154-C recorder is *attenuating automatically* to keep peaks on scale, the Printing Integrator will follow the recorder through attenuation changes and present compensated integrals at analysis' end.

The peak areas, added and normalized, give gross concentration percentages. Introducing thermal conductivity coefficients, where necessary, will give quantitative measurements six to ten times as precise as pip-marking methods or conventional physical measurement of the chart peaks.

The Model 194 ($1,375 f.o.b. Norwalk, Conn.) employs a standard velocity servo computer. At full scale, the Integrator produces 6000 counts per minute, or 1263 per square inch of chart space. The recorder pen/count linearity is within ±0.3%, averaged over full scale.

For more information, write for "Automatic Printed Integration of Recorder Data," to 910 Main Avenue, Norwalk, Conn.

Price subject to change without notice.

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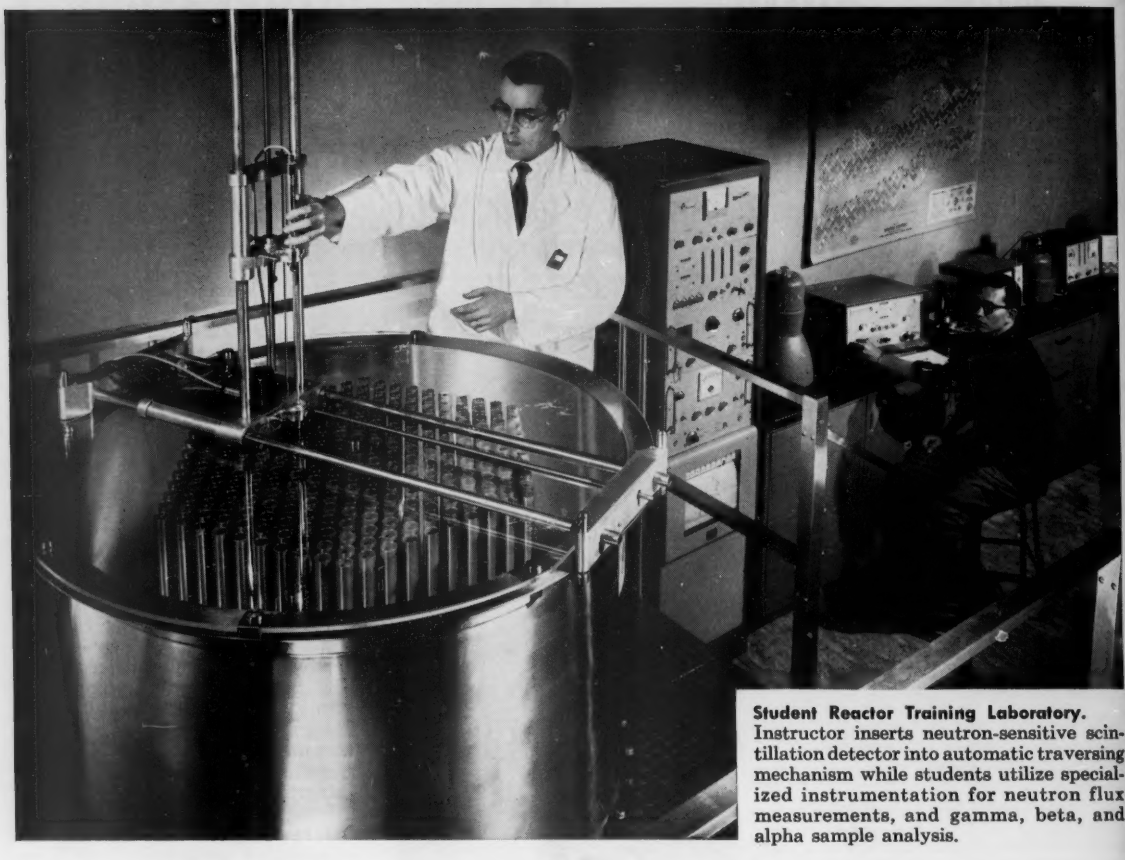

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